# Section 206
# Flood Plain Management Services

# New Hampshire Dam-Break Study
# Harrisville, New Hampshire

November 1995

US Army Corps
of Engineers
New England Division

# DAM-BREAK FLOOD ANALYSES
# SILVER LAKE, CHILDS BOG, SEAVERS RESERVOIR, AND CHESHAM POND DAMS

## MINNEWAWA BROOK
## HARRISVILLE, NEW HAMPSHIRE

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# DAM-BREAK FLOOD ANALYSES
# SILVER LAKE, CHILDS BOG, SEAVERS RESERVOIR, AND CHESHAM POND DAMS

## 1. INTRODUCTION

This report presents the findings of dam-break flood analyses performed for the Minnewawa Brook reservoir system including: Silver Lake, Childs Bog, Seavers Reservoir, and Chesham Pond dams. These dams are owned, operated, and maintained by the New Hampshire Department of Environmental Services, Water Resources Division. Included in the report appendices are descriptions of pertinent features of the dams, procedures used for the analyses, assumed dam-break conditions, and the resulting effect on downstream flooded areas, particularly the town of Marlborough. This study was not performed because of any known likelihood of a dam-break at any of these dams. The purpose is to provide information for emergency planning use.

## 2. PURPOSE

These dam-break flood analyses were conducted at the request of the State of New Hampshire, under the authority of the Corps of Engineers Section 206 Flood Plain Management Services (FPMS) program. This report presents the findings of dam-break analyses performed for both sunny day (approximate normal inflow into pool) and flood (estimated September 1938 flood of record inflow into pool) conditions.

## 3. WATERSHED DESCRIPTION

Minnewawa Brook is a small stream located in the southwestern part of New Hampshire. Discharges from a system of dammed ponds control the headwaters of Minnewawa Brook in Harrisville, New Hampshire. Outflow from Silver Lake and Childs Bog flow into Seavers Reservoir. Discharges from Seavers Reservoir flows into Chesham Pond and forms Minnewawa Brook. About one mile downstream of Chesham Pond, flows from Howe Reservoir enter Minnewawa Brook. The brook flows southwesterly through the town of Marlborough, New Hampshire, for about six miles until its confluence with Otter Brook which forms the Branch River, a tributary to the Ashuelot River. The topography of the drainage area is moderately to steeply sloped and primarily wooded.

## 4. VALLEY DESCRIPTION

The valley downstream of this system of reservoirs is relatively flat and primarily sparsely populated in the town of Harrisville, New Hampshire. There are several structures near Minnewawa Brook in the village of Chesham, about one half mile downstream of Chesham Pond dam. In addition, there are three road crossings in Harrisville. The brook has a slope of about 15 feet per mile in this reach. When the stream enters Marlborough, the valley becomes well defined and channel slope increases to 120 feet per mile to the end of the study reach. Minnewawa Brook flows about two miles before crossing under three unimproved roadways. About one-half mile further downstream, the brook flows through downtown Marlborough, where there are numerous habitable structures and five road crossings before the brook leaves town, about one mile downstream.

A minimum number of detailed surveys of the stream channel and crossings were performed as part of this study. These were supplemented with surveys obtained from a previous Corps of Engineers dam-break study for Howe Reservoir.

## 5. MODEL DESCRIPTION

Dam-break analyses for four impoundments were made using Boss Corporation's 1992 release of the National Weather Service Dam-Break Flood Forecasting Computer Model developed by D.L. Fread. Input for the model consists of storage characteristics of the reservoirs, selected geometry and duration of breach development, and hydraulic roughness coefficients for the downstream channel. Detailed descriptions of this information are discussed in individual appendices for each dam. Based on input data, the model computes the breach outflow hydrograph and routes it downstream. The analyses provide output on the attenuation of flood stages, and timing of the flood wave as it progresses downstream. These results are also discussed in detail in each appendix.

## 6. DAM-BREAK CONDITIONS

The magnitude of the flood resulting from the hypothetical failure of a dam is a function of many different parameters including size of breach, initial pool

level and associated storage, rate of breach formation, channel and overbank roughness, and antecedent flow conditions. Engineering assumptions of conditions, which could be reasonably expected to exist prior to a failure of the dam, were used in the analyses presented in the appendices.

Computed flood elevations are presented in relation to feet above Normal Low Water (NLW) because below water channel geometry was known for relatively few downstream sections and detailed survey information was only obtained at each of the dams. NLW is the approximate normal summertime (July and August) low water, which can be estimated as about one foot of flow depth. Users of the information can determine depth of flooding at particular properties by establishing its relative elevation, with respect to the adjacent stream level. Variations in depth above NLW progressing downstream, are attributable to changes in natural stream hydraulic capacity as well as changes in peak discharge.

Two scenarios were analyzed for each dam. The sunny day failure assumes a piping failure occurs at normal pool elevation with a typical "nonevent" inflow to the impoundment. The "nonevent" inflow used for each run varied between 100 and 200 cfs, depending on the stability of the initial condition run for the dam-break model. Piping failures occur when initial breach formation takes place at some point below the top of the dam, due to erosion of an internal channel through the dam by escaping water. The flood event failure was modelled by assuming that inflow to the dam is equal to the flood of record, September 1938. Initial pool elevation is at the test flood elevation presented in the Phase I Inspection Report for each dam, and failure begins when water overtopping the dam causes erosion and opens a breach through the dam.

A summary of the results of these analyses are presented in table 1. Detailed information about each reservoir and discussion of results of these scenarios, including flood profiles, are presented in Appendices A through D.

In addition, several hypothetical multiple dam-break scenarios were analyzed. Different combinations of multi-dam failures were simulated and routed downstream to Marlborough. Dam-break parameters used in these simulations are similar to those used for each individual dam-break scenario and are described in Appendices A through D. Besides analyzing combinations of the four dams in the Minnewawa Brook headwaters, the consequences of a concurrent failure at Howe Reservoir was studied. Results of all of the multiple failures are discussed in Appendix E.

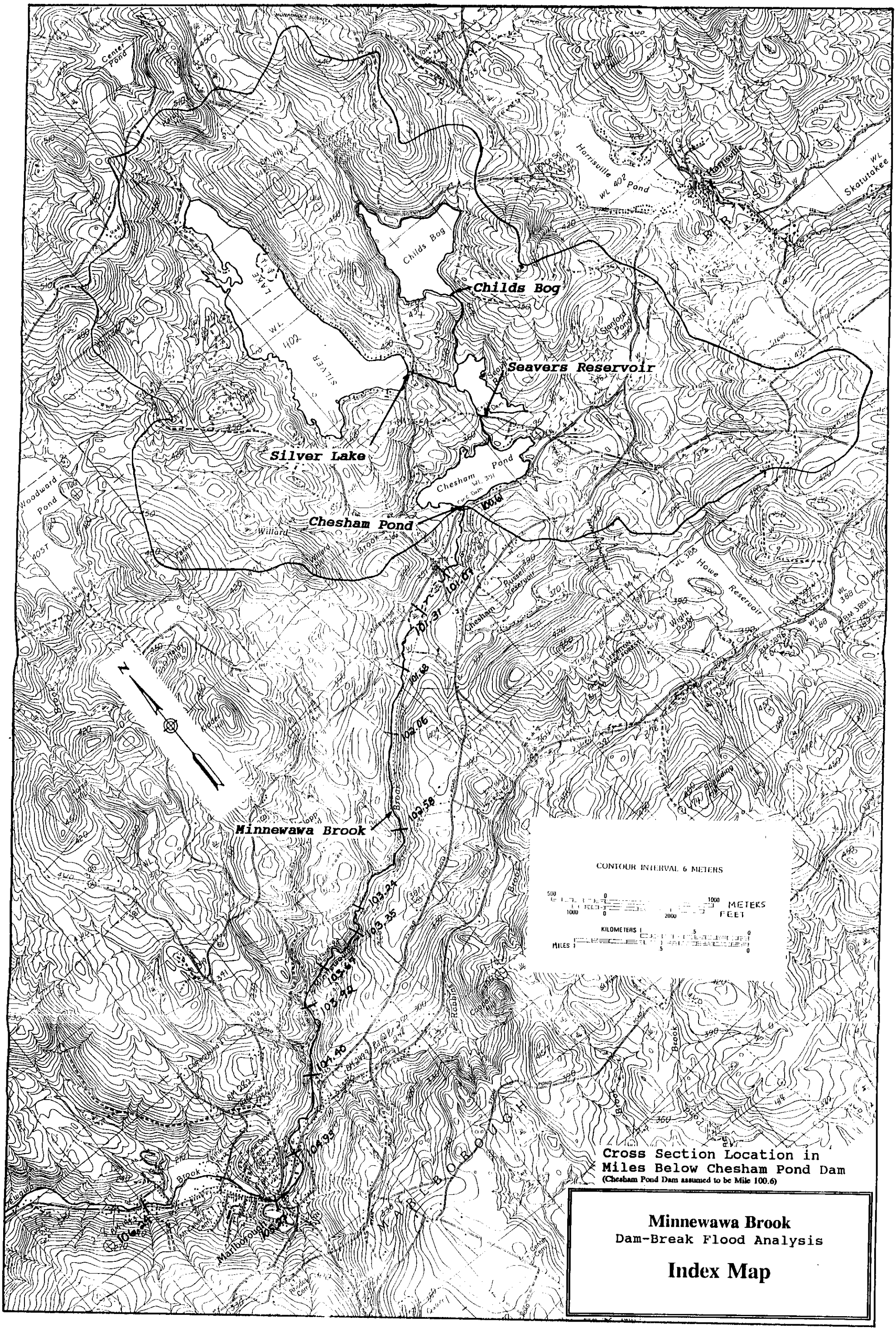
TABLE 1

Summary of Peak Discharges, Stages, and Timing
Minnewawa Brook Dam-Break Scenarios

| Dam-Break Scenario | Upper Dam | | | Chesham Pond | | | Marlborough Sta 105.27 | | |
|---|---|---|---|---|---|---|---|---|---|
| | Flow (cfs) | Stage (NLW) | Time[1] | Flow (cfs) | Stage (NLW) | Time[1] | Flow (cfs) | Stage (NLW) | Time[1] |
| Chesham Pond Dam | - | - | - | 12060 | 14.5 | 1.0 | 5990 | 17.8 | 2.4 |
| Seavers Reservoir Dam | 19340 | 14.3 | 1.0 | 13980 | 19.6 | 1.0 | 6920 | 19.0 | 2.2 |
| Childs Bog Dam | 7400 | 11.5 | 1.0 | 5770 | 15.3 | 1.8 | 4100 | 13.1 | 3.2 |
| Silver Lake Dam | 8750 | 11.0 | 1.0 | 7590 | 16.8 | 1.8 | 6090 | 17.9 | 3.8 |
| Silver Lake & Seavers Reservoir Combined Failure | - | - | - | 15590 | 16.6 | 1.8 | 10140 | 19.9 | 3.8 |
| Silver Lake, Seavers Reservoir, Chesham Pond Combined Failure | - | - | - | 17722 | 18.2 | 2.1 | 11910 | 20.9 | 3.3 |
| Childs Bog, Seavers Reservoir, Chesham Pond Combined Failure | - | - | - | 16100 | 17.3 | 2.0 | 10970 | 20.8 | 3.2 |
| All Minnewawa Brook Dams Failure | - | - | - | 24760 | 22.1 | 1.9 | 17410 | 24.8 | 3.2 |
| All Minnewawa Brook Dams and Howe Reservoir Failure[2] | - | - | - | 24760 | 22.1 | 1.9 | 40070 | 32.4 | 2.9 |

[1]Time is in hours from start of dambreak failure.
[2]Estimated peak dam-break discharge from Howe and Russell Reservoirs is 24,410 cfs (based on the November 1985 "Howe Reservoir Dam, Dam-Break Flood Analysis Report").

Differences in amount of attenuation and timing of peak discharges are due primarily to differences in the volume of flood water in the breach hydrographs.


Childs Bog
Seavers Reservoir
Silver Lake
Chesham Pond
Minnewawa Brook
Harrisville
Pond
Stanford Pond
Howe Reservoir
Russell Reservoir
Wright Pond
Center Pond
Woodward Pond
Willard Brook
Parker Hill
Kidder Hill
Derby Hill
Blood Hill
Cooper Hill
Robbins
Marlborough
Skatutakee
WL 402
WL 391
WL 388
CONTOUR INTERVAL 6 METERS
METERS
FEET
KILOMETERS
MILES
Cross Section Location in Miles Below Chesham Pond Dam
(Chesham Pond Dam assumed to be Mile 100.6)
Minnewawa Brook
Dam-Break Flood Analysis
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# APPENDIX A

## DAM-BREAK FLOOD ANALYSIS
## CHESHAM POND DAM

# DAM-BREAK FLOOD ANALYSIS
# CHESHAM POND DAM

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# DAM-BREAK FLOOD ANALYSIS
# CHESHAM POND DAM

## 1. DAM DESCRIPTION

Chesham Pond Dam is located on the southwestern end of the impoundment. It is the downstream dam in a series of four dams which impound the headwaters of Minnewawa Brook. Chesham Pond receives it inflow from Seavers Reservoir, located about 1,000 feet upstream. The surrounding land is primarily wooded with some sparsely placed habitable structures. Total drainage area of Chesham Pond is 8.2 square miles, however, 4.38 square miles of this watershed is located above Seavers Reservoir. Information listed in table 1 was taken from the National Dam Inspection Program "Phase I Inspection Report, Chesham Pond Dam," March 1980.

TABLE 1

General Dam Information

| | |
|---|---|
| *Name of Dam* | Chesham Pond Dam |
| *Identification Number* | NH00063 |
| *Town* | Harrisville |
| *County and State* | Cheshire, NH |
| *Stream* | Minnewawa Brook |

Chesham Pond Dam (shown on plate A-1) is a concrete gravity dam and earthen abutment 125 feet long with a hydraulic height of 16 feet above streambed and top of dam elevation of 1156.4 feet NGVD. The spillway consists of a concrete ogee spillway 41 feet in length with a crest elevation of 1154.0 feet NGVD. A concrete sluiceway structure is adjacent to the northwest end of the spillway and contains a gate-operated, low-level outlet 2 feet high by 3.5 feet wide. The gate can be operated by hand using a mechanism located directly above the gate. A highway crossing is located immediately downstream of the dam. Stone masonry training walls, located on either side of the spillway discharge channel, terminate against the highway embankment. Flows pass under the roadway in a corrugated metal pipe arch 10 feet 2 inches high and 14 feet 11 inches wide.

## 2. PERTINENT DATA

The following information was taken from the Phase I Inspection Report for Chesham Pond Dam.

a. Drainage Area. Chesham Pond Dam controls a drainage area of 8.2 square miles of moderately to steeply sloping terrain. Silver Lake, Childs Bog, and Seaver Reservoir are located in the upstream watershed.

b. Elevations (feet NGVD)

(1) Top of dam - 1156.4
(2) Spillway crest - 1154.0

c. Reservoir Surface (acres)

(1) Spillway crest - 70 acres
(2) Top of dam - 84 acres

d. Reservoir Storage (acre-feet)

(1) Spillway crest - 460 acre-feet
(2) Top of dam - 630 acre-feet

e. Dam

(1) Type - concrete gravity dam with earth embankment
(2) Length - 125 feet
(3) Height - 16 feet above streambed
(4) Topwidth - varies
(5) Side Slopes
upstream varies: vertical to 1V:1.5H
downstream varies: vertical to 1V:2H
(6) Impervious core - unknown
(7) Cutoff - unknown
(8) Grout curtain - unknown

f. Spillway

(1) Type - concrete gravity ogee spillway with sloping downstream face (1H:1V)
(2) Length of weir - 41 feet
(3) Crest elevation - 1154.0 feet NGVD
(4) Gates - none
(5) Upstream channel - Reservoir

g. Regulating Outlet

(1) Invert - 1146.6 feet NGVD
(2) Size - 2 feet high by 3.5 feet wide
(3) Description - low-level sluiceway opening
(4) Control - cast iron sluice gate

3. ASSUMED DAM-BREAK CONDITIONS

Two hypothetical dam-break scenarios were analyzed. The sunny-day and flood event cases. Dam-break parameters used in the model are listed below.

a. Initial Pool Level:

(1) Sunny day - 1154.0 feet NGVD (spillway crest elevation)
(2) Flood event - 1161.2 feet NGVD (test flood elevation from Phase I inspection report)

b. Reservoir Inflow

(1) Sunny day - 100 cfs
(2) Flood event - 2,020 cfs (est. September 1938)

c. Breach Invert

(1) Sunny day - 1143.0 feet NGVD
(2) Flood event - 1143.0 feet NGVD

d. Breach Base Width

(1) Sunny day - 40 feet with 1V:1H side slopes
(2) Flood event - 50 feet with 1V:1H side slopes

e. Time to Complete Formation of Breach: 1.0 hour

f. Downstream Channel Roughness (Mannings "n"): 0.06 to 0.14

4. MODEL RESULTS

Resulting peak stage flood profiles for both the flood event and sunny day dam-break scenarios are shown on plates A-2 and A-3. Profiles are shown in feet above normal summertime (July-August) low water (NLW) because below water channel geometry was known for relatively few downstream sections and detailed survey information was only obtained at each of the dams. Users of the information can establish

depth of flooding at particular properties by establishing its relative elevation with respect to the adjacent stream level. Variations in depth above NLW progressing downstream are attributable to changes in natural stream hydraulic capacity as well as changes in peak discharge.

For the dam-break analyses, the stream channel below Chesham Pond was modeled in two reaches. The first reach is from the dam at Chesham Pond to river station 103.24, about 13,900 feet (2.64 miles) downstream. The roadway immediately downstream of the dam is assumed to washout during the dam-break analyses. The second reach extends from station 103.35 to the end of the study beyond the Town of Marlborough at station 106.24 (about 29,800 feet, 5.64 miles, below Chesham Pond). The outflow hydrograph of the first reach was used as the inflow hydrograph to the second reach.

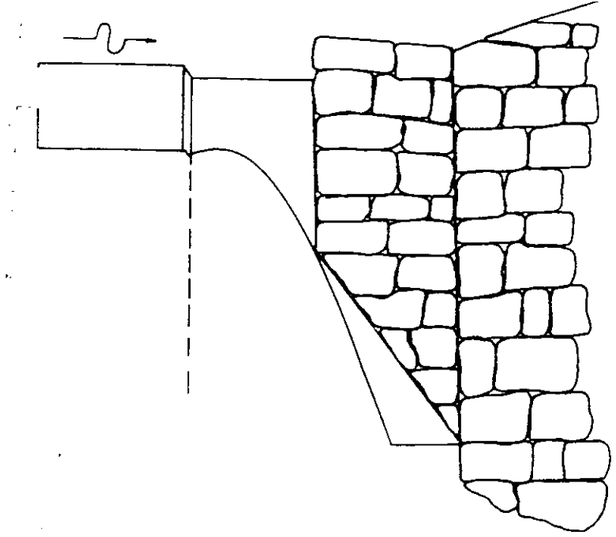
Outflow from two impoundments on a tributary stream, Howe and Russell Reservoirs, enters Minnewawa Brook about 6,900 feet (1.3 miles) below Chesham Pond dam. Estimated flood event discharge from these impoundments is 2,400 cfs (based on the September 1938 flood of record). Dam-break modelling was performed both with and without this additional discharge entering Minnewawa Brook. Analysis of resulting peak stages at the downstream limit of study in Marlborough revealed only a minor difference between the two cases because significant attenuation occurs throughout the river valley. As a result, final adopted dam-break simulations were performed without including this flow.

a. Flood Event. Flood event simulation assumes that inflow to the impoundment is approximately equal to the September 1938 flood of record, and that the dam fails by overtopping. Peak dam-break discharge from Chesham Pond dam is 12,060 cfs producing a rise of approximately 14.6 feet above the NLW river elevation at a point 50 feet (0.01 miles) downstream of the dam. At station 101.31, 3,700 feet (0.71 miles) below the dam, peak discharge is about 9,960 cfs with an associated rise over NLW stage of about 16.1 feet. At 24,700 feet (4.67 miles) below Chesham Pond, in the Town of Marlborough, peak discharge is 5,990 cfs with an associated rise over NLW stage of 17.8 feet occurring approximately 2.4 hours from the start of breach formation.

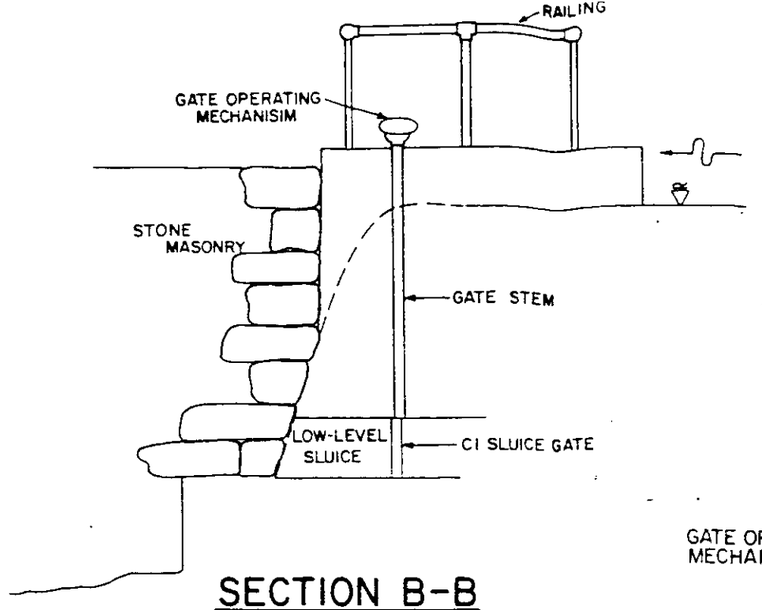
Peak discharge, stages, and timing associated with the storm event for the three stations downstream of Chesham Pond dam are shown on plate A-4. The stations are located 50, 3,700, and 24,700 feet below the dam.

b. Sunny Day. In addition to the storm day failure, a sunny day failure simulation of Chesham Pond was also performed. A sunny day failure assumes that a piping failure of the dam occurs during normal inflow to the pool. No storm event is associated with this type of failure simulation. Peak dam-break discharge from Chesham Pond dam for the sunny day breach is 4,120 cfs producing a rise of approximately 7.9 feet above the NLW river elevation at a point 50 feet (0.01 miles) downstream of the dam. At station 101.31, 3,700 feet (0.71 miles) below the dam, peak discharge is about 2,920 cfs with an associated rise over NLW stage of about 8.8 feet. At 24,700 feet (4.67 miles) below Chesham Pond, in the Town of Marlborough, peak discharge is 1,620 cfs with an associated rise over NLW stage of 9.6 feet occurring approximately 2.85 hours from the start of the breach formation.

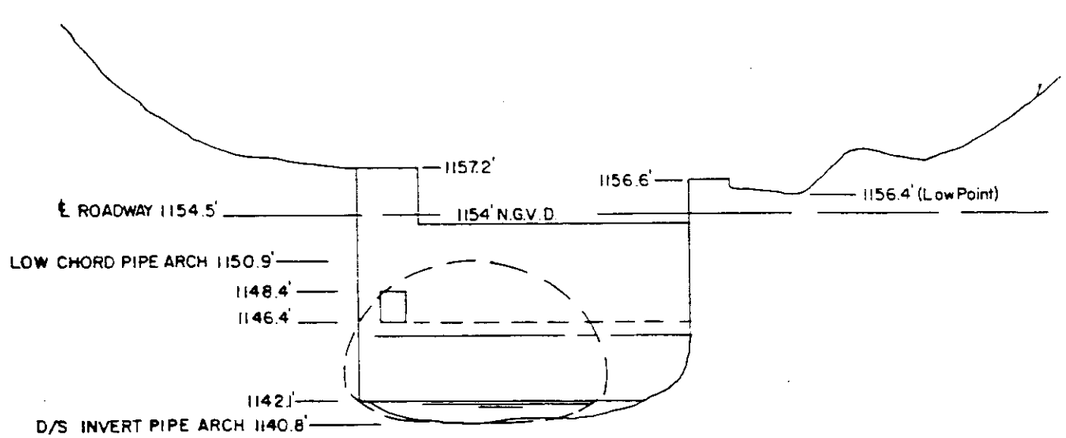
Since the storm day failure results in a more severe flood with higher peak flows and flood elevations downstream of the dam, flood discharges, stages, and timing are not graphically depicted for the sunny day events, however, hydrograph shapes and timing are similar for both cases. Flood profiles comparing the storm and sunny day events are shown on plates A-2 and A-3.



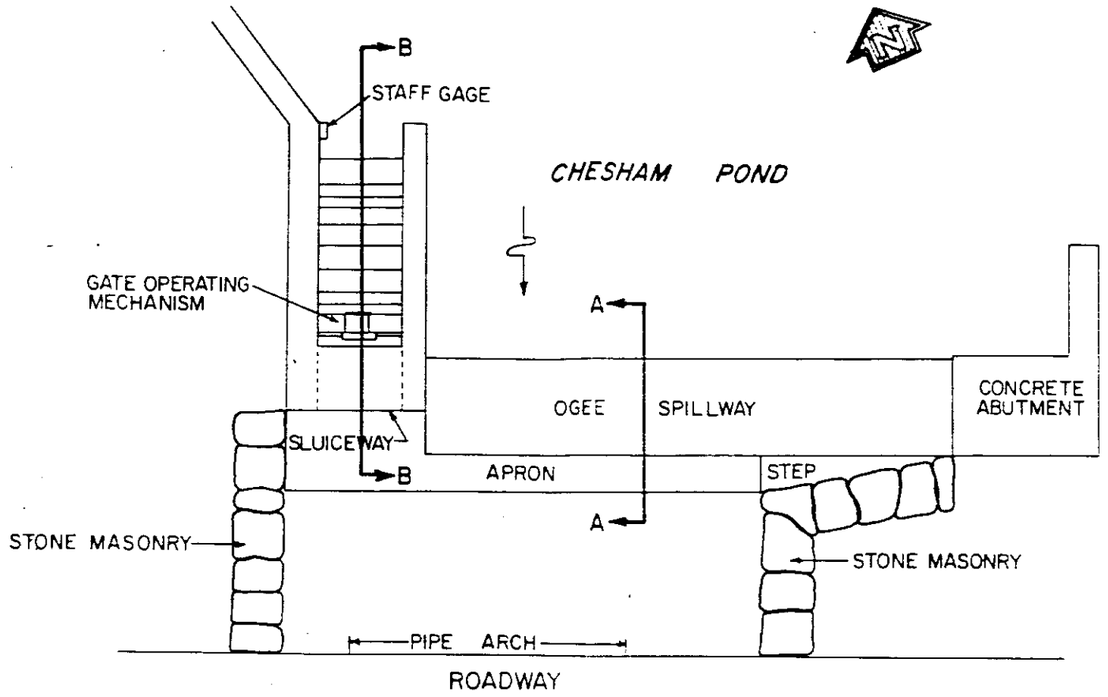
SECTION A-A




SECTION B-B




ELEVATION




PLAN

NOTE: ALL ELEVATIONS ARE BASED ON SPILLWAY CREST ASSUMED ELEVATION OF 1154' N.G.V.D.

| | |
|---|---|
| Anderson-Nichols & Co., Inc. CONCORD NEW HAMPSHIRE | U.S. ARMY ENGINEER DIV. NEW ENGLAND CORPS OF ENGINEERS WALTHAM, MA. |

NATIONAL PROGRAM OF INSPECTION OF NON-FED. DAMS

# CHESHAM POND DAM

MINNEWAWA BROOK NEW HAMPSHIRE

SCALE: NOT TO SCALE

DATE: MARCH 1980

PLATE A-1

Childs Bog

Silver Lake

Seaver Res.

Chesham Pond

Harrisville

Marlborough

Chesham Pond Dam

Town Line

1.0

1.9

Storm Day Dam Failure

Sunny Day Dam Failure

Assumed Pre-Breach

Normal Low Water

101.07

101.31

101.68

102.06

102.58

103.24

Elevation in Feet NGVD

1350
1325
1300
1275
1250
1225
1200
1175
1150

0 1 2 3 4 5

Distance in 1,000 Feet Downstream of Childs Bog

Stage Above N.L.W. (Feet)

15
10
5
0

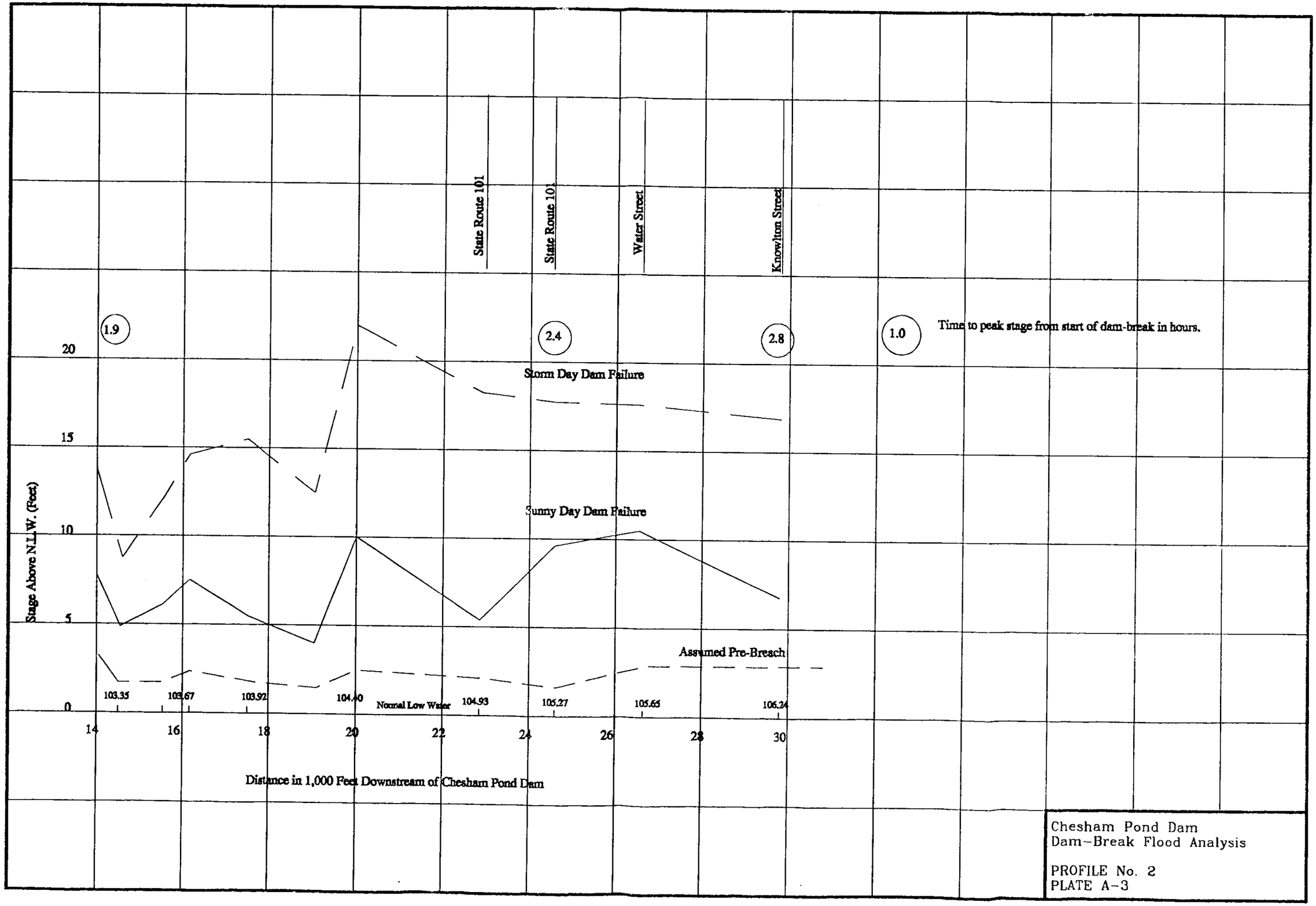
0 2 4 6 8 10 12 14

Distance in 1,000 Feet Downstream of Chesham Pond Dam

1.0 Time to peak stage from start of dam-break in hours.

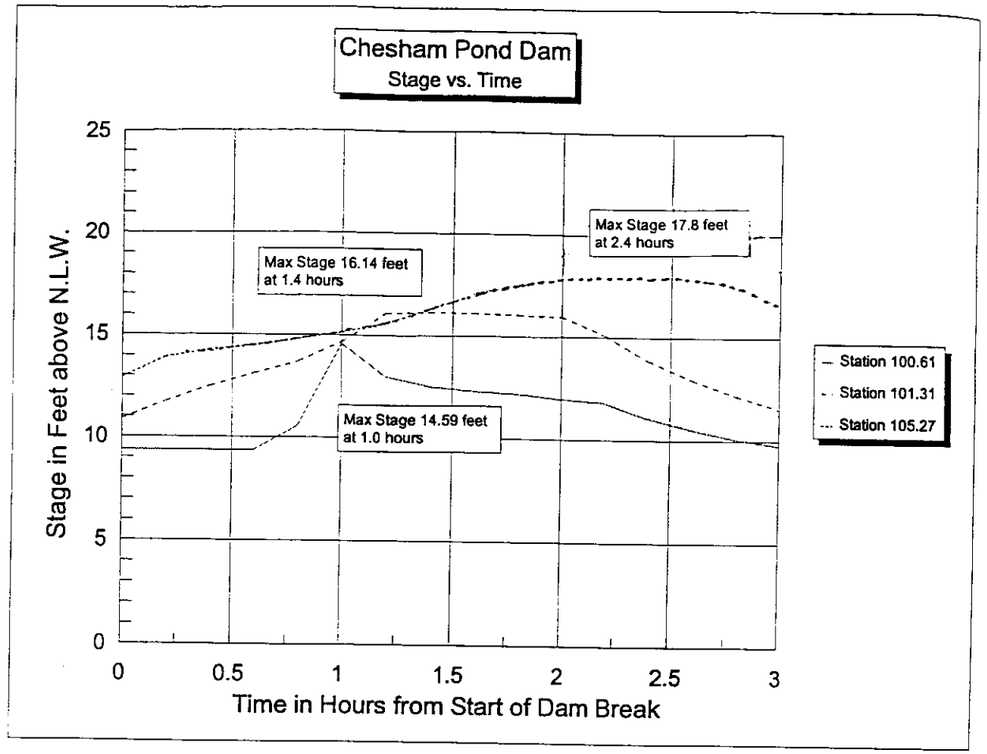
Chesham Pond Dam
Dam-Break Flood Analysis

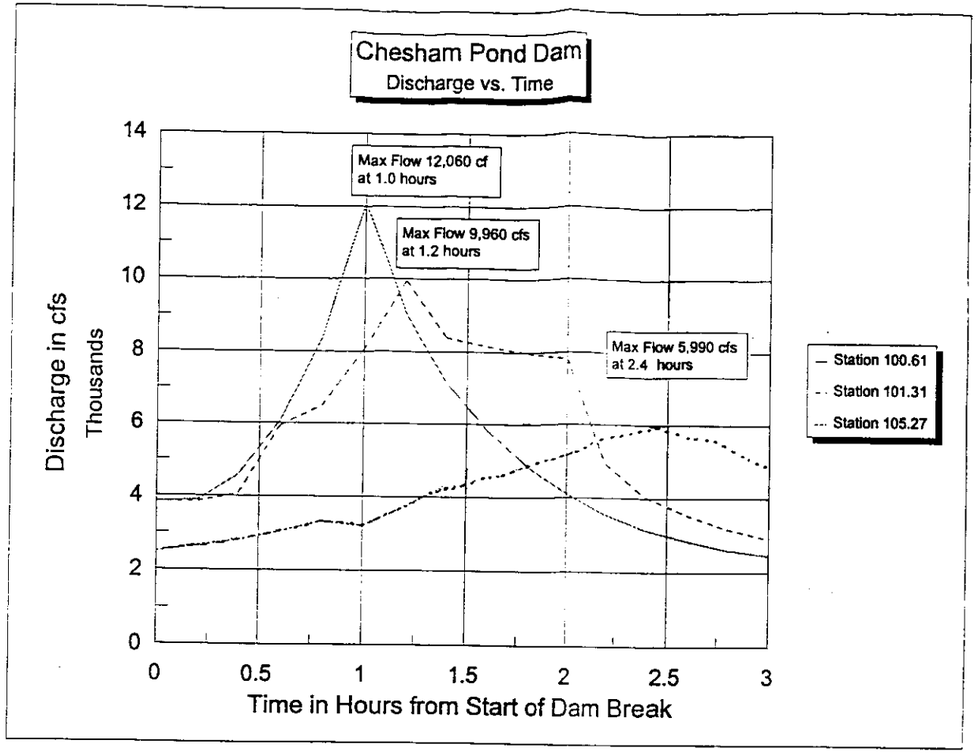
PROFILE No. 1
PLATE A-2

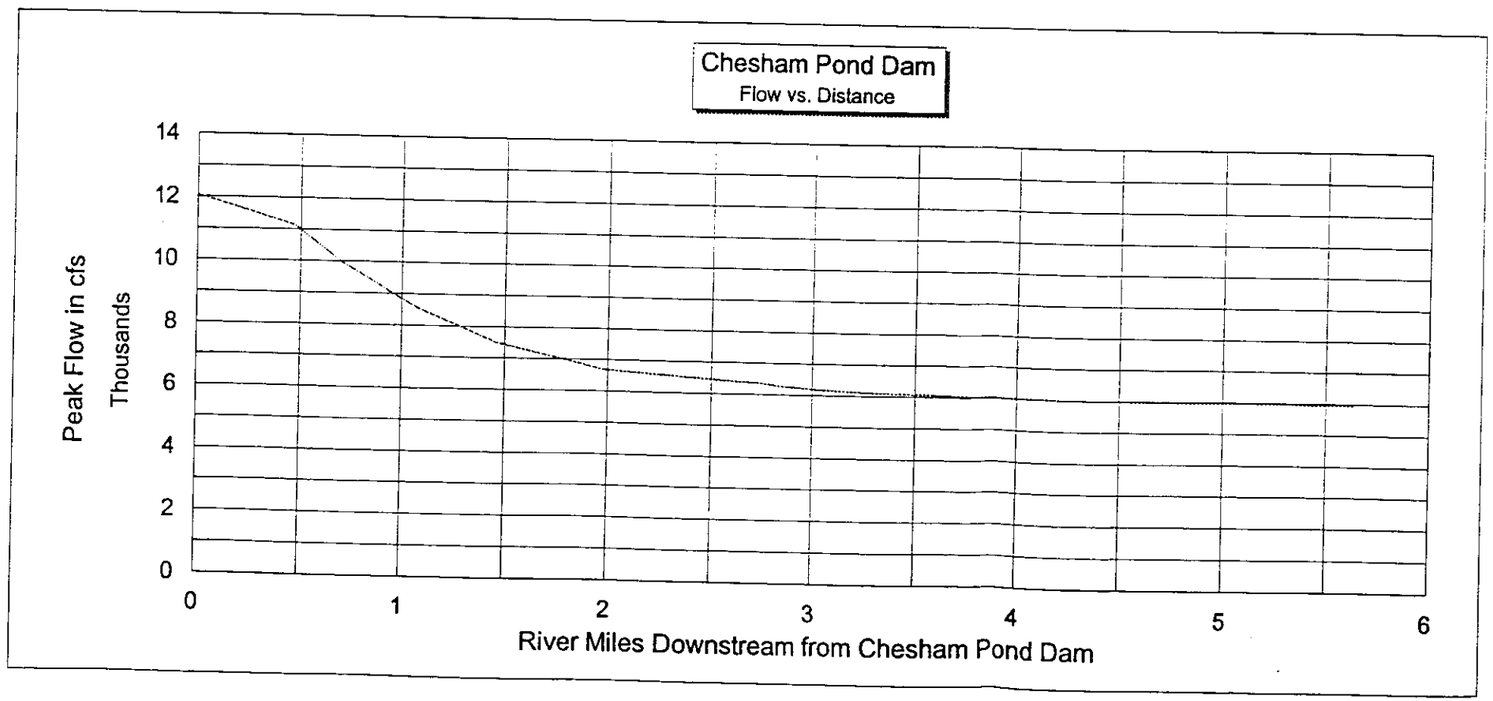



Chesham Pond Dam
Dam-Break Flood Analysis

PROFILE No. 2
PLATE A-3




N.L.W. Datum (Ft. NGVD)
Sta 100.61 = 1136.8
Sta 105.27 = 705.6

**Chesham Pond Dam**
Dam-Break Flood Analysis

**Base Flood Discharge Stages and Timing**

PLATE A-4

# APPENDIX B

# DAM-BREAK FLOOD ANALYSIS
# SEAVERS RESERVOIR DAM

# DAM-BREAK FLOOD ANALYSIS
# SEAVERS RESERVOIR DAM

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# DAM-BREAK FLOOD ANALYSIS
# SEAVERS RESERVOIR DAM

## 1. DAM DESCRIPTION

Seavers Reservoir Dam is located on the southwestern end of the impoundment. It is the second most downstream dam in a series of four dams which impound the headwaters of Minnewawa Brook. Seavers Reservoir receives inflow from Silver Lake and Childs Bog Dams, each located about one-half of a mile upstream. Discharges from Seavers Reservoir flow through Chesham Pond and into Minnewawa Brook. The land surrounding Seavers Reservoir is primarily wooded with some sparsely placed habitable structures. Total drainage area of Seavers Reservoir is 4.38 square miles, however, 3.65 square miles of this watershed is located above Silver Lake and Childs Bog. Information listed in table 1 was taken from the National Dam Inspection Program "Phase I Inspection Report, Seavers Reservoir Dam," July 1979.

TABLE 1

General Dam Information

| | |
|---|---|
| *Name of Dam* | Seavers Reservoir |
| *Identification Number* | NH00094 |
| *Town* | Harrisville |
| *County and State* | Cheshire, NH |
| *Stream* | Minnewawa Brook |

Seavers Reservoir Dam (shown on plate B-1 and B-2) is an earthfill dam 325 feet long with a hydraulic height of 28 feet above streambed and top of dam elevation of 1204.3 feet NGVD. The spillway consists of a 4-foot square concrete drop inlet with a crest elevation of 1201.0 feet NGVD. This discharges into a horizontal 36-inch diameter reinforced concrete pipe outlet which is controlled by a 4-foot square low-level gate. An earthen emergency spillway, 120 feet long with a crest elevation of 1202.3 feet NGVD, is located on the southeastern point of the reservoir.

## 2. PERTINENT DATA

The following information was taken from the Phase I Inspection Report for Seavers Reservoir Dam.

a. Drainage Area. Seavers Reservoir Dam controls a drainage area of 4.38 square miles of moderately to steeply sloping terrain. Silver Lake and Childs Bog are located in the upstream watershed.

b. Elevations (feet NGVD)

(1) Top of dam - 1204.3
(2) Spillway crest - 1201.0
(3) Emergency spillway crest - 1202.3

c. Reservoir Surface (acres)

(1) Spillway crest - 45 acres
(2) Emergency spillway crest - 48 acres
(3) Top of dam - 52 acres

d. Reservoir Storage (acre-feet)

(1) Spillway crest - 466 acre-feet
(2) Emergency spillway crest - 555 acre-feet
(3) Top of dam - 680 acre-feet

e. Dam

(1) Type - earthen embankment with drop-inlet spillway and earthen emergency spillway
(2) Length - 325 feet (does not include 120 foot emergency spillway)
(3) Height - 28 feet above streambed
(4) Topwidth - 30 feet
(5) Side Slopes
upstream: 1V:2H
downstream: 1V:1.5H
(6) Impervious core - none
(7) Cutoff - 4 feet deep by 4 to 8 feet wide
(8) Grout curtain - none

f. Spillway

(1) Type - vertical concrete drop inlet riser which discharges into a 36-inch horizontal concrete pipe
(2) Size - 4-foot square drop inlet riser
(3) Crest elevation - 1201.0 feet NGVD
(4) Gates - none
(5) Upstream channel - Reservoir

g. Regulating Outlet

(1) Invert - 1176.5 feet NGVD
(2) Size - 3-foot square concrete conduit which discharges into a 36-inch diameter concrete pipe controlled by a slide gate
(3) Description - low-level sluiceway opening
(4) Control - steel slide gate

3. ASSUMED DAM-BREAK CONDITIONS

Two hypothetical dam-break scenarios were analyzed. The sunny-day and flood event cases. Dam-break parameters used in the model are listed below.

a. Initial Pool Level:

(1) Sunny day - 1201.0 feet NGVD (spillway crest elevation)
(2) Flood event - 1205.6 feet NGVD (test flood elevation from Phase I inspection report)

b. Reservoir Inflow

(1) Sunny day - 200 cfs
(2) Flood event - 1,300 cfs (est. September 1938)

c. Breach Invert

(1) Sunny day - 1179.5 feet NGVD
(2) Flood event - 1179.5 feet NGVD

d. Breach Base Width

(1) Sunny day - 85 feet with 1V:1H side slopes
(2) Flood event - 85 feet with 1V:1H side slopes

e. Time to Complete Formation of Breach: 1.0 hour

f. Downstream Channel Roughness (Mannings "n"): 0.06 to 0.14

4. MODEL RESULTS

Resulting peak stage flood profiles for both the flood event and sunny day dam-break scenarios are shown on plates B-3 and B-4. Profiles are shown in feet above normal summertime (July-August) low water (NLW) because below water channel geometry was known for relatively few downstream

sections and detailed survey information was only obtained at each of the dams. Users of the information can establish depth of flooding at particular properties by establishing its relative elevation with respect to the adjacent stream level. Variations in depth above NLW progressing downstream are attributable to changes in natural stream hydraulic capacity as well as changes in peak discharge.

For the dam-break analyses, the stream channel below Chesham Pond was modeled in two reaches. The first reach is from the dam at Seavers Reservoir through Chesham Pond to river station 103.24, about 13,900 feet (2.64 miles) downstream. The second reach extends from station 103.35 to the end of the study beyond the Town of Marlborough at station 106.24 (about 29,800 feet, 5.64 miles, below Chesham Pond). The outflow hydrograph of the first reach was used as the inflow hydrograph to the second reach.

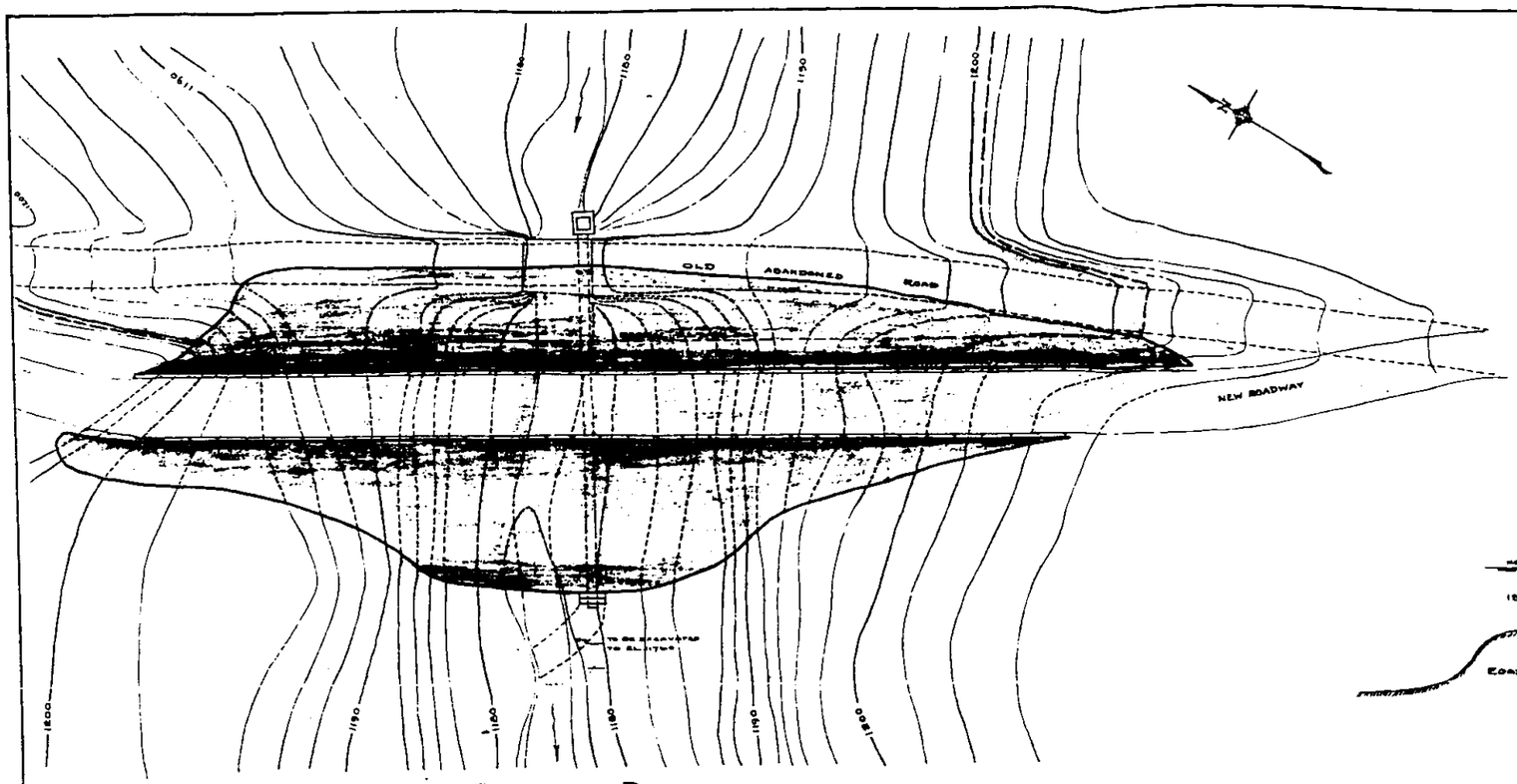
Outflow from two impoundments on a tributary stream, Howe and Russell Reservoirs, enters Minnewawa Brook about 6,900 feet (1.3 miles) below Chesham Pond dam. Estimated flood event discharge from these impoundments is 2,400 cfs (based on the September 1938 flood of record). Dam-break modelling was performed both with and without this additional discharge entering Minnewawa Brook. Analysis of resulting peak stages at the downstream limit of study in Marlborough revealed only a minor difference between the two cases because significant attenuation occurs throughout the river valley. As a result, final adopted dam-break simulations were performed without including this flow.

a. Flood Event. Flood event simulation assumes that inflow to the impoundment was approximately equal to the flood of record, September 1938, and that the dam fails by overtopping. Peak dam-break discharge from Seavers Reservoir dam for the flood event is 19,340 cfs producing a rise of approximately 14.25 feet above the NLW river elevation at a point 100 feet (0.02 miles) downstream of the dam. This floodwave was routed through Chesham Pond assuming that the initial impoundment was filled to spillway crest and that Chesham Pond dam does not fail (since this is a single failure simulation). At the station 50 feet (0.01 mile) below Chesham Pond dam, peak discharge is about 13,980 cfs with an associated rise over NLW stage of about 19.6 feet. At 24,700 feet (4.67 miles) below Chesham Pond, in the Town of Marlborough, peak discharge is 6,920 cfs with an associated rise over NLW stage of 18.97 feet occurring approximately 2.0 hours from the start of the breach formation at Seavers Reservoir dam.

Peak discharge, stages, and timing associated with the storm event for the three stations downstream of Seavers Reservoir dam are shown on plate B-5. The stations are located 100 feet below Seavers Reservoir, and 50 and 24,700 feet below Chesham Pond dam.

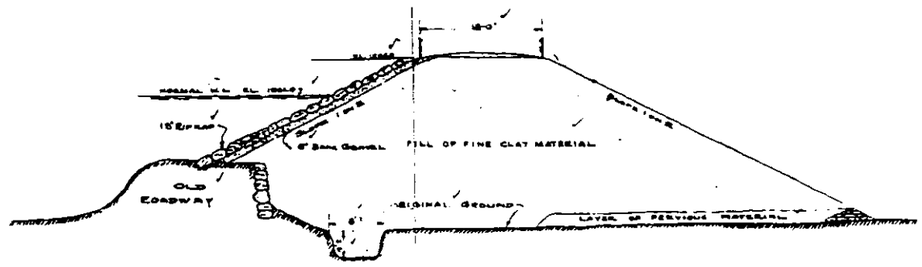
b. Sunny Day. In addition to the storm day failure, a sunny day failure simulation of Seavers Reservoir was also performed. A sunny day failure assumes that a piping failure of the dam occurs during normal inflow to the pool. No storm event is associated with this type of failure simulation. Peak discharge from Seavers Reservoir dam for the sunny day breach is 15,320 cfs producing a rise of approximately 12.3 feet above the NLW river elevation at a point 100 feet (0.02 miles) downstream of the dam. This floodwave was routed through Chesham Pond assuming that the initial impoundment was filled to spillway crest and that Chesham Pond dam does not fail. At the station 50 feet (0.01 mile) below Chesham Pond dam, peak discharge is about 8,240 cfs with an associated rise over NLW stage of about 16.9 feet. At 24,700 feet (4.67 miles) below Chesham Pond, in the Town of Marlborough, peak discharge is 3,190 cfs with an associated rise over NLW stage of 15.4 feet occurring approximately 2.6 hours from the start of the sunny day breach formation at Seavers Reservoir dam.

Since the storm day failure results in a more severe flood with higher peak flows and flood elevations downstream of the dam, flood discharges, stages, and timing are not graphically depicted for the sunny day event, however, hydrograph shapes and timing are similar for both cases. Flood profiles comparing the storm and sunny day events are shown on plates B-3 and B-4.

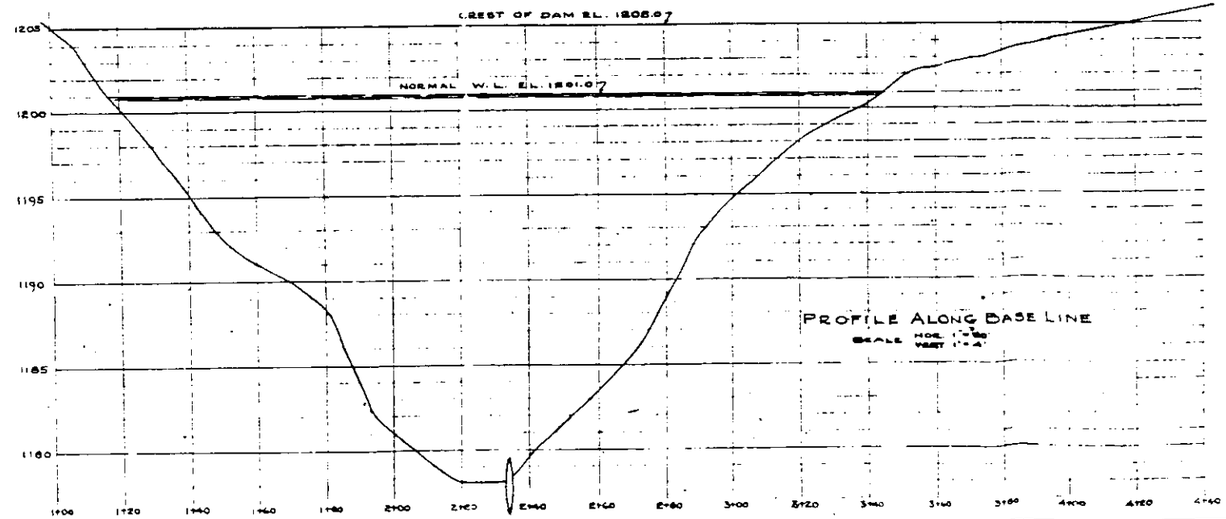



PLAN OF DAM
SCALE 1" = 20'

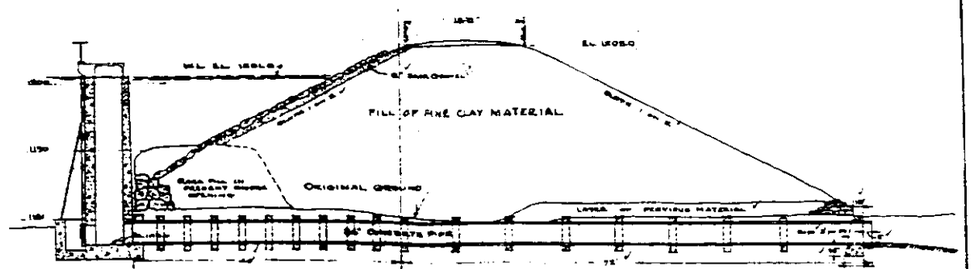

SECTION AT STA. 3+00
SCALE 1"=10'




SECTION AT STA. 2+50
SCALE 1"=10'




PROFILE ALONG BASE LINE
SCALE HOR. 1"=20'
VERT 1"=4'

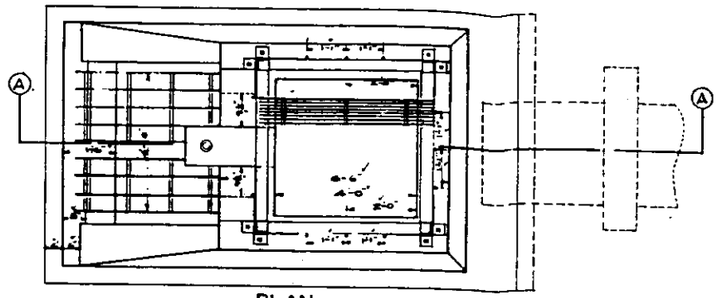



SECTION THRU SLUICE PIPE
SCALE 1"=10'

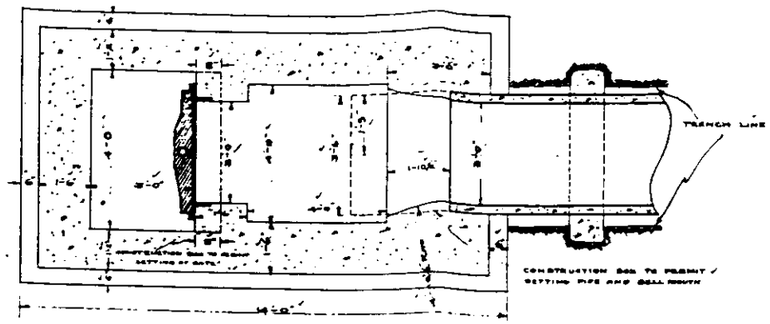
ASHUELOT GAS & ELECTRIC CO.
MINNEWAWA DEVELOPMENT
SEAVER RESERVOIR DAM
HARRISVILLE, N.H.
PLAN AND SECTIONS
SCALE AS NOTED L.M. SHATTUCK, INC. ENGRS
FEBRUARY 1934 MANCHESTER, N.H.
C.A. Shaw CHIEF ENGINEER

PLATE B-1

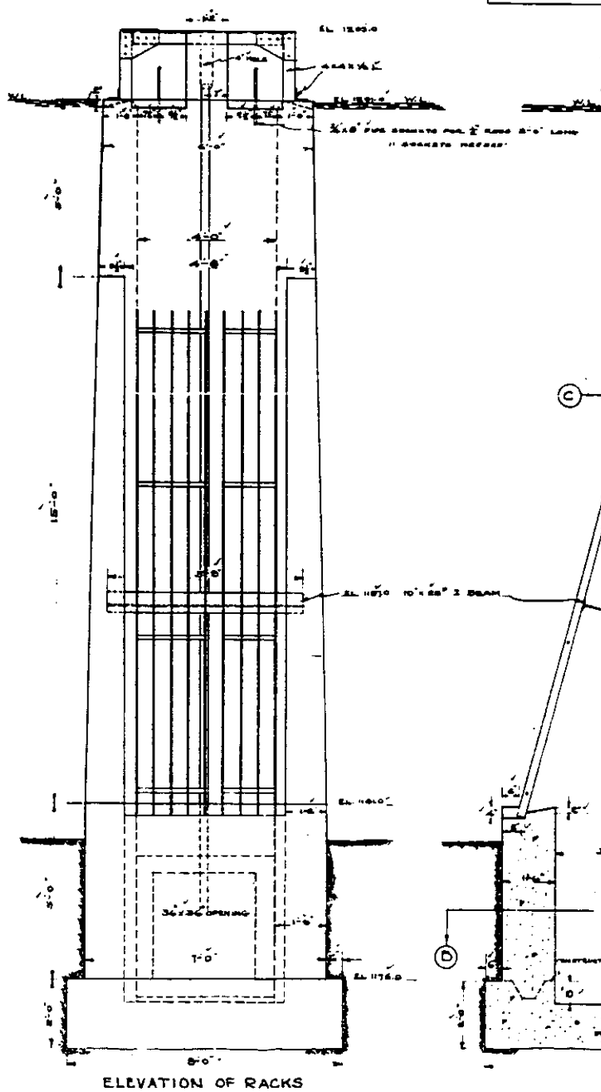
ORIGINAL BY DATE
DESIGNED
DRAWN
TRACED
CHECKED
APPROVED
ISSUE
REVISION
MADE BY DATE CHECKED BY DATE



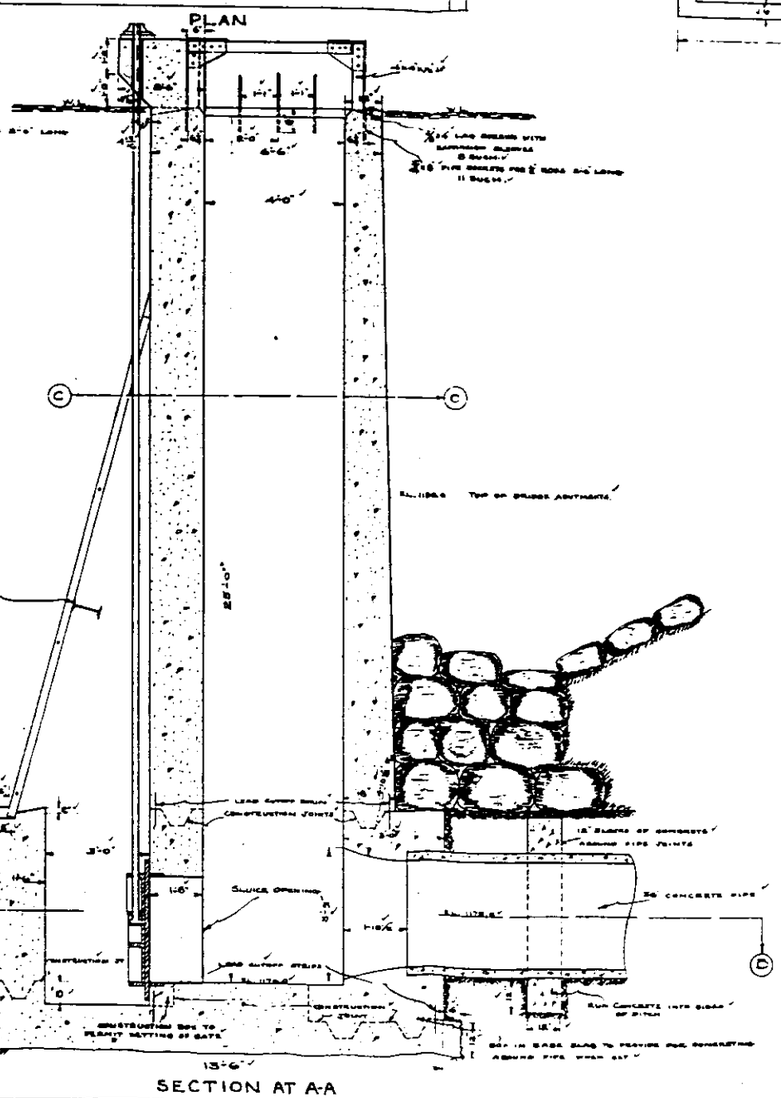
PLAN



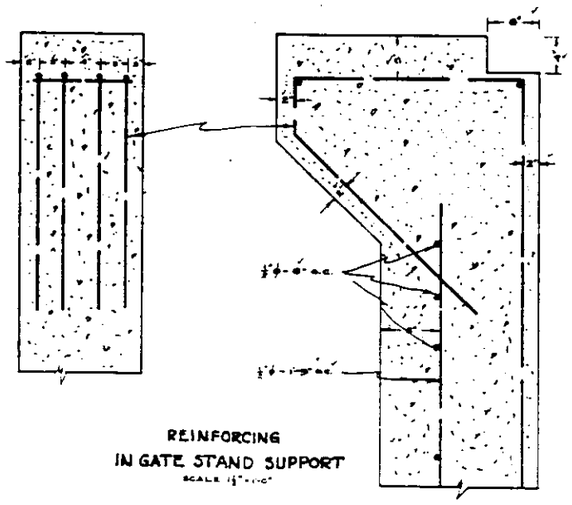

SECTION AT B-B



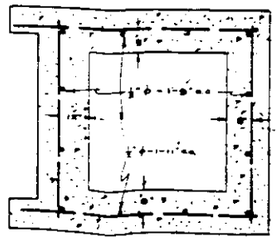
ELEVATION OF RACKS



SECTION AT A-A



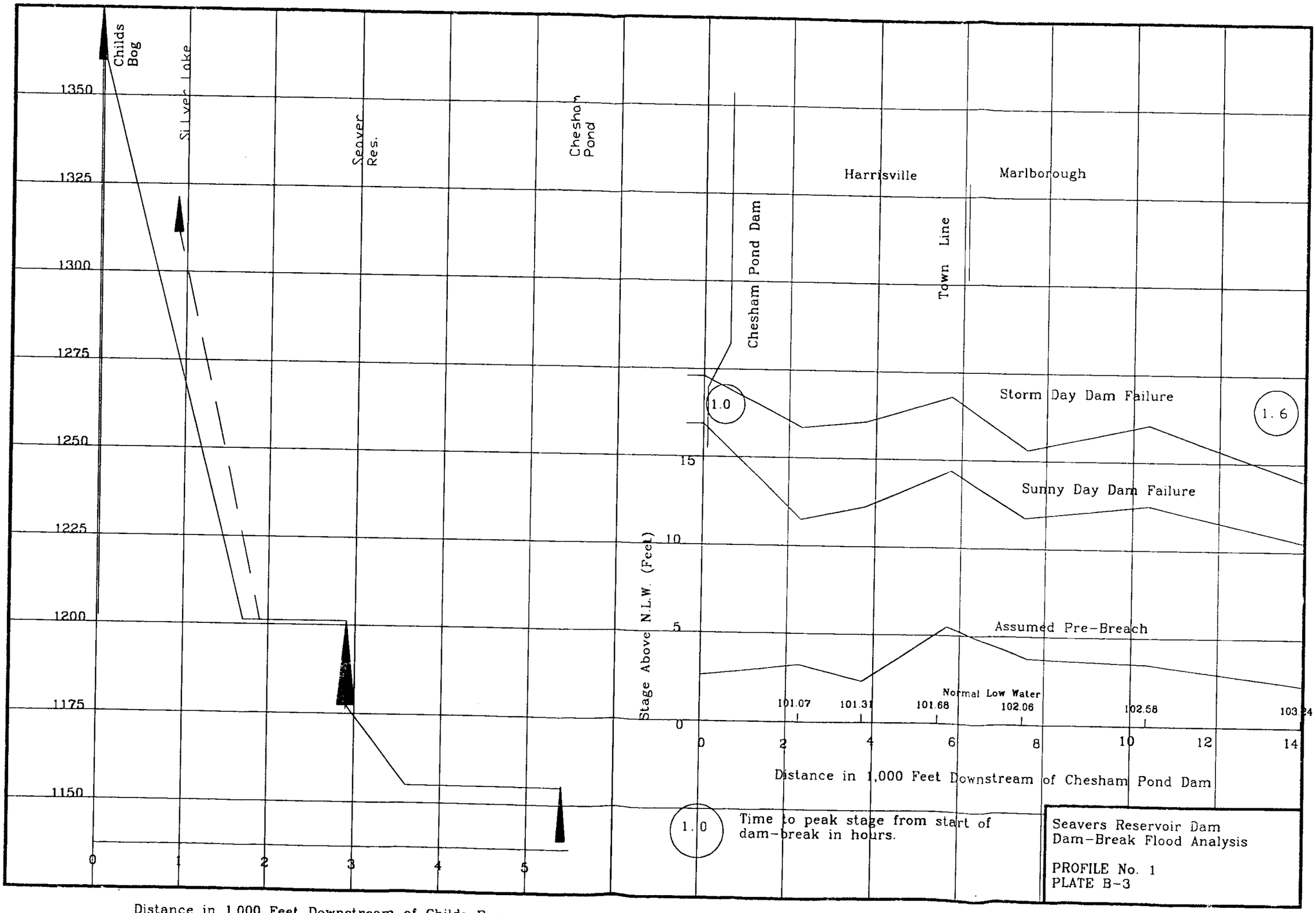
REINFORCING
IN GATE STAND SUPPORT

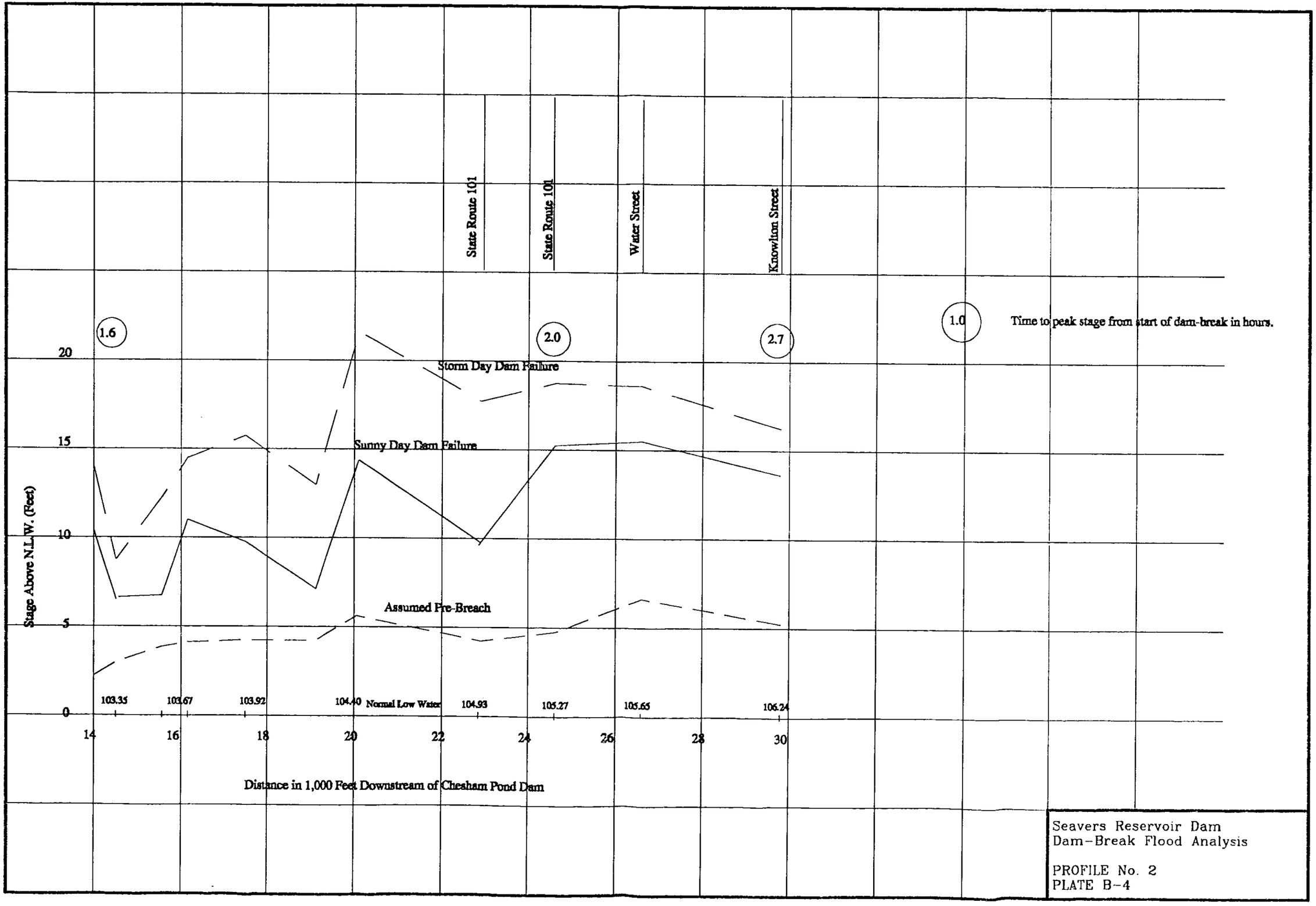


SECTION AT 'C-C'

ASHUELOT GAS & ELECTRIC CO.
MINNEWAWA DEVELOPMENT
SEAVER RESERVOIR DAM
HARRISVILLE, N.H.
OUTLET AND SPILLWAY CHAMBER
SCALE 1/4"=1'-0" L.H. SHATTUCK, INC. ENGRS.
FEBRUARY 1954 MANCHESTER, N.H.
C.H. Shaw CHIEF ENGINEER

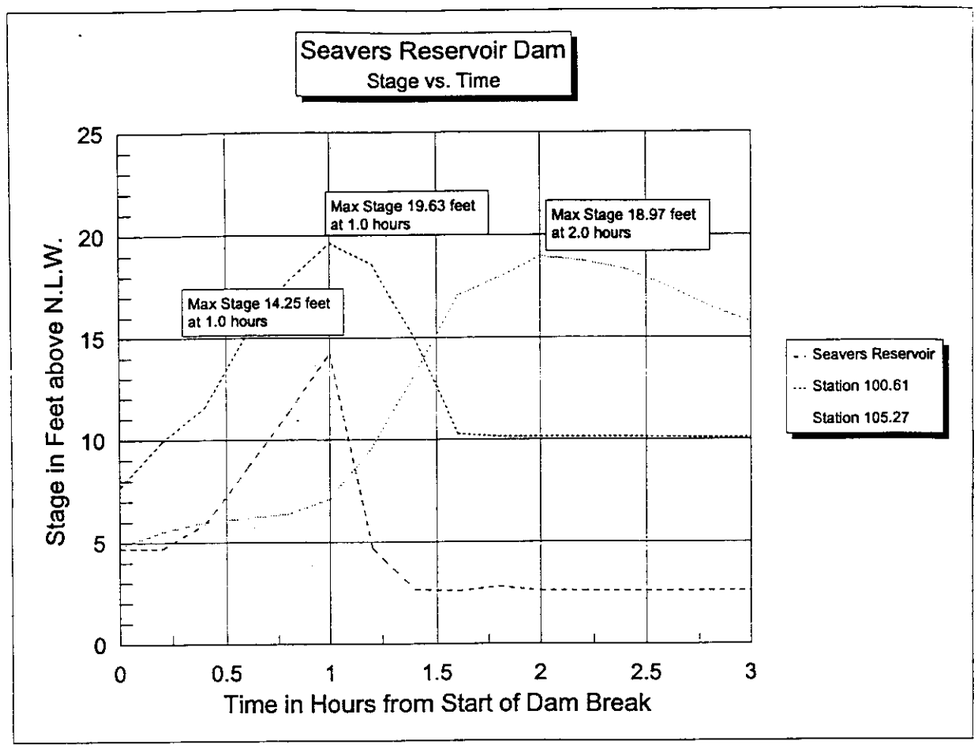
PLATE B-2

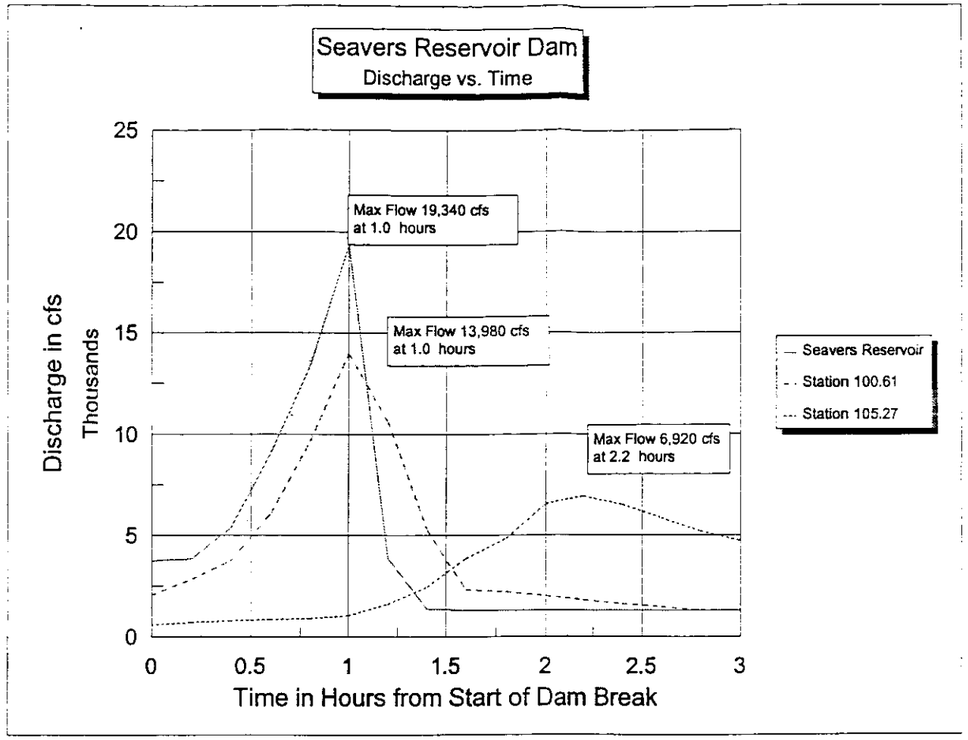

Childs Bog
Silver Lake
Seaver Res.
Chesham Pond
Harrisville
Marlborough
Chesham Pond Dam
Town Line
Storm Day Dam Failure
Sunny Day Dam Failure
Assumed Pre-Breach
Normal Low Water
101.07
101.31
101.68
102.06
102.58
103.24
1.0
1.6
Elevation in Feet NGVD
1350
1325
1300
1275
1250
1225
1200
1175
1150
0
1
2
3
4
5
Distance in 1,000 Feet Downstream of Childs Bog
Stage Above N.L.W. (Feet)
15
10
5
0
0
2
4
6
8
10
12
14
Distance in 1,000 Feet Downstream of Chesham Pond Dam
1.0
Time to peak stage from start of dam-break in hours.
Seavers Reservoir Dam
Dam-Break Flood Analysis
PROFILE No. 1
PLATE B-3

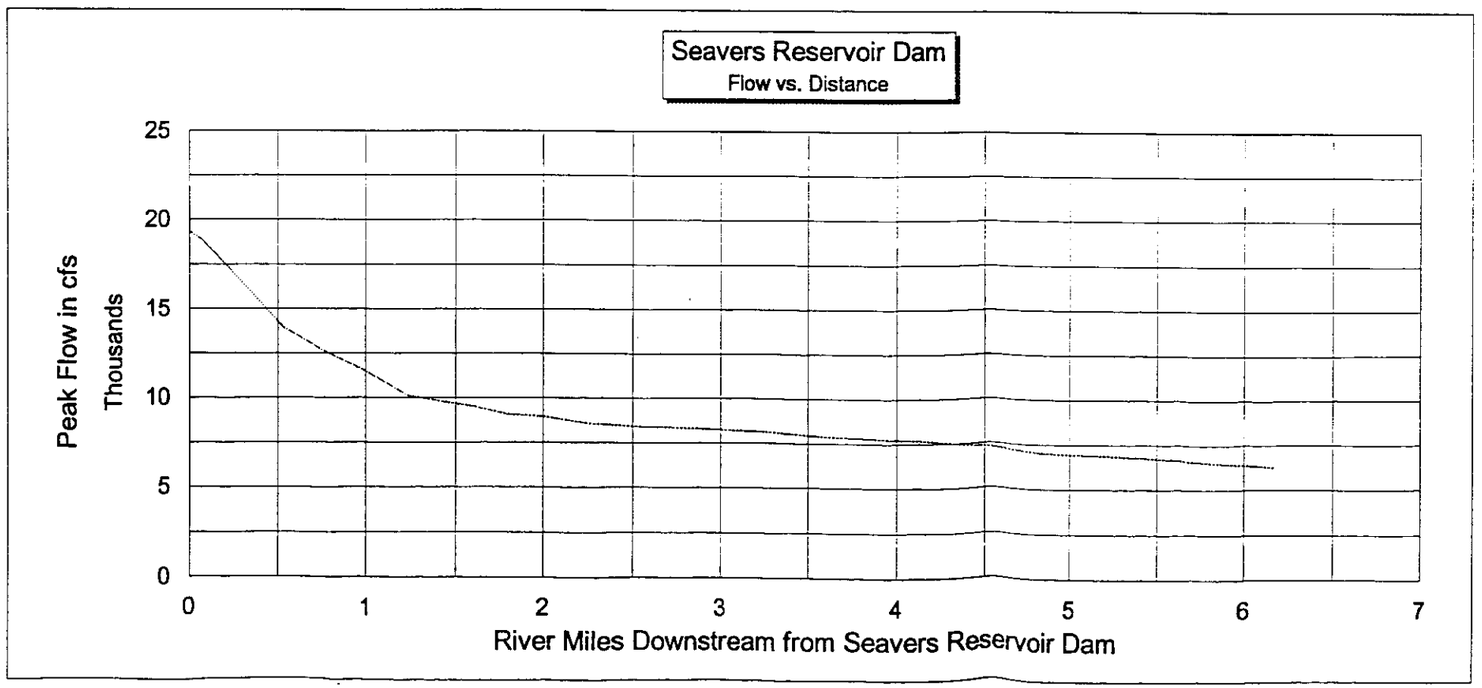



Seavers Reservoir Dam
Dam-Break Flood Analysis

PROFILE No. 2
PLATE B-4




N.L.W. Datum (Ft. NGVD)
Sta 100.61 = 1136.8
Sta 105.27 = 705.6

**Seavers Reservoir Dam**
Dam-Break Flood Analysis

**Base Flood Discharge Stages and Timing**

PLATE B-5

# APPENDIX C

## DAM-BREAK FLOOD ANALYSIS
## CHILDS BOG DAM

# DAM-BREAK FLOOD ANALYSIS
# CHILDS BOG DAM

## TABLE OF CONTENTS



## LIST OF PLATES

# DAM-BREAK FLOOD ANALYSIS
# CHILDS BOG DAM

## 1. DAM DESCRIPTION

Childs Bog Dam is located on the southeastern point of the impoundment. It is one of the most upstream dams in a series of four dams which impound the headwaters of Minnewawa Brook. Outflow from Childs Bog flows through Seavers Reservoir and then Chesham Pond before emptying into Minnewawa Brook, located about one and one-half miles downstream. The surrounding land is primarily wooded with some sparsely placed habitable structures. Total drainage area of Childs Bog is 1.41 square miles. Information listed in table 1 was taken from the National Dam Inspection Program "Phase I Inspection Report, Childs Bog Dam," July 1979.

TABLE 1

General Dam Information

| | |
|---|---|
| *Name of Dam* | Childs Bog Dam |
| *Identification Number* | NH00096 |
| *Town* | Harrisville |
| *County and State* | Cheshire, NH |
| *Stream* | Minnewawa Brook |

Childs Bog Dam (shown on plate C-1) is a rockfill, concrete-capped, stone masonry dam with a nearly vertical downstream face and a 1V:1.5H sloping upstream face. The dam is 206 feet long with a hydraulic height of 14.5 feet above streambed and top of dam elevation of 1376.5 feet NGVD. The spillway consists of a 157-foot long concrete-capped stone masonry weir centered in the dam with a crest elevation of 1376.0 feet NGVD. The dam has a drain gate near the center of the spillway at the base of the structure. Flows through the 2.5-foot square gate with an invert elevation of 1362.0 feet NGVD pass through an 18-foot long culvert and discharge into the downstream channel.

## 2. PERTINENT DATA

The following information was taken from the Phase I Inspection Report for Childs Bog Dam.

a. Drainage Area. Childs Bog Dam controls a drainage area of 1.41 square miles (896 acres). This area is primarily wooded mountainous terrain.

b. Elevations (feet NGVD)

(1) Top of dam - 1376.5
(2) Spillway crest - 1376.0

c. Reservoir Surface (acres)

(1) Spillway crest - 134 acres
(2) Top of dam - 138 acres

d. Reservoir Storage (acre-feet)

(1) Spillway crest - 1,200 acre-feet
(2) Top of dam - 1,280 acre-feet

e. Dam

(1) Type - rockfill concrete-capped, stone masonry dam with concrete apron
(2) Length - 206 feet
(3) Height - 14.5 feet above streambed
(4) Topwidth - minimum width 1 foot
(5) Side Slopes
upstream: 1V:1.5H
downstream: nearly vertical
(6) Impervious core - none, rockfill
(7) Cutoff - concrete
(8) Grout curtain - unknown

f. Spillway

(1) Type - concrete-capped stone masonry centered along dam
(2) Length of weir - 157 feet
(3) Crest elevation - 1376.0 feet NGVD
(4) Gates - none
(5) Upstream channel - Reservoir

g. Regulating Outlet

(1) Invert - 1362.0 feet NGVD
(2) Size - inclined 2.5-foot square opening discharges through an 18-foot long conduit
(3) Description - low-level spillway drain gate
(4) Control - steel gate with mechanism above on concrete platform

3. ASSUMED DAM-BREAK CONDITIONS

Two hypothetical dam-break scenarios were analyzed. The sunny-day and flood event cases. Dam-break parameters used in the model are listed below.

a. Initial Pool Level:

(1) Sunny day - 1376.0 feet NGVD (spillway crest elevation)
(2) Flood event - 1378.5 feet NGVD (test flood elevation from Phase I inspection report)

b. Reservoir Inflow

(1) Sunny day - 200 cfs
(2) Flood event - 590 cfs (est. September 1938)

c. Breach Invert

(1) Sunny day - 1364.5 feet NGVD
(2) Flood event - 1364.5 feet NGVD

d. Breach Base Width

(1) Sunny day - 50 feet with 1V:1H side slopes
(2) Flood event - 50 feet with 1V:1H side slopes

e. Time to Complete Formation of Breach: 1.0 hour

f. Downstream Channel Roughness (Mannings "n"): 0.06 to 0.14

4. MODEL RESULTS

Resulting peak stage flood profiles for both the flood event and sunny day dam-break scenarios are shown on plates C-2 and C-3. Profiles are shown in feet above normal summertime (July-August) low water (NLW) because below water channel geometry was known for relatively few downstream

sections and detailed survey information was only obtained at each of the dams. Users of the information can establish depth of flooding at particular properties by establishing its relative elevation with respect to the adjacent stream level. Variations in depth above NLW progressing downstream are attributable to changes in natural stream hydraulic capacity as well as changes in peak discharge.

For the dam-break analyses, the stream channel below Childs Bog was modeled in three reaches. The first reach is from Childs Bog dam to Seavers Reservoir. The next reach is from the dam at Seavers Reservoir through Chesham Pond to river station 103.24, about 13,900 feet (2.64 miles) downstream. The last reach extends from station 103.35 to the end of the study beyond the Town of Marlborough at station 106.24 (about 29,800 feet, 5.64 miles, below Chesham Pond). The outflow hydrograph of the first reach was used as the inflow hydrograph to the second reach. Similar methodology was applied for the second and third reaches.

Outflow from two impoundments on a tributary stream, Howe and Russell Reservoirs, enters Minnewawa Brook about 6,900 feet (1.3 miles) below Chesham Pond dam. Estimated flood event discharge from these impoundments is 2,400 cfs (based on the September 1938 flood of record). Dam-break modelling was performed both with and without this additional discharge entering Minnewawa Brook. Analysis of resulting peak stages at the downstream limit of study in Marlborough revealed only a minor difference between the two cases because significant attenuation occurs throughout the river valley. As a result, final adopted dam-break simulations were performed without including this flow.

a. Flood Event. Flood event simulation assumes that inflow to the impoundment was approximately equal to the flood of record, September 1938, and that the dam fails by overtopping. Peak discharge from Childs Bog for the storm day failure is 7,400 cfs resulting a river stage rise of about 11.5 feet above NLW immediately downstream of the dam. After being routed through Seavers Reservoir dam, assuming initial pool at spillway crest and no dam failure, resulting peak discharge is 6,040 cfs producing a rise of approximately 6.4 feet above the NLW river elevation at a point 100 feet (0.02 miles) downstream of the dam. This floodwave was routed through Chesham Pond assuming that the initial impoundment was filled to spillway crest and that Chesham Pond dam does not fail. At the station 50 feet (0.01 mile) below Chesham Pond dam, peak discharge is about 5,770 cfs with an associated rise over NLW stage of about 15.3 feet. At 24,700 feet (4.67 miles) below Chesham Pond,

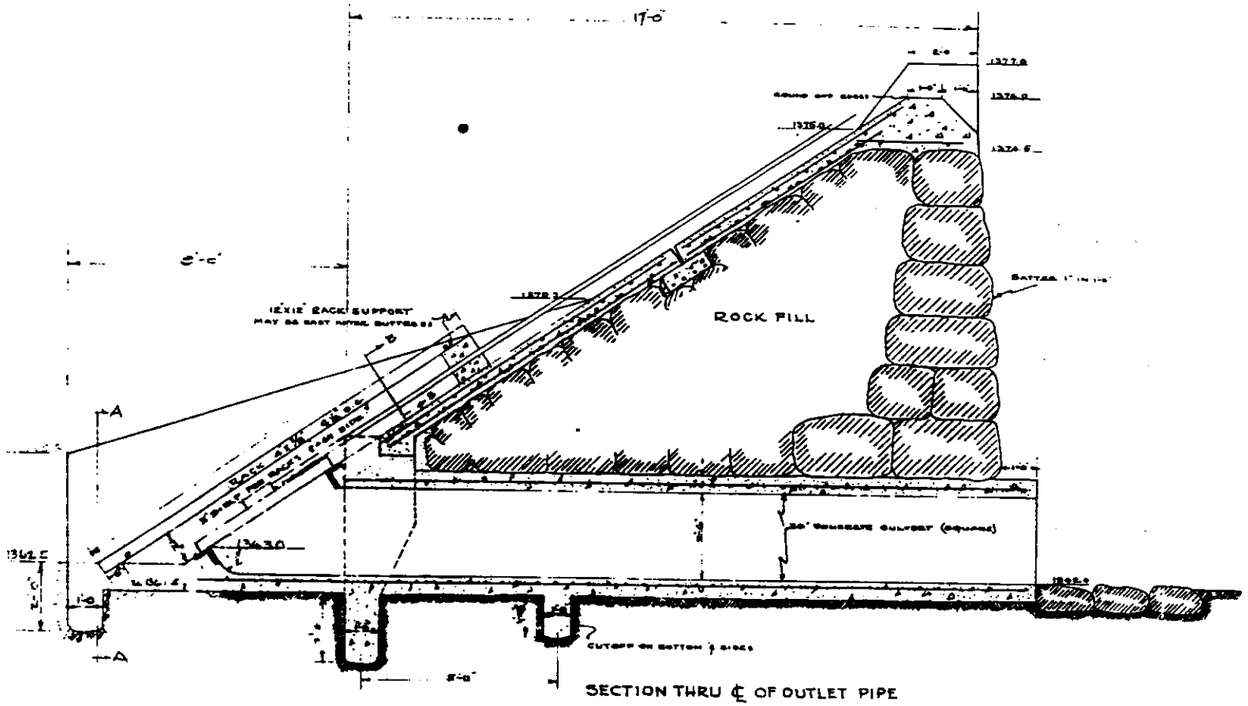
in the Town of Marlborough, peak discharge is 4,100 cfs with an associated rise over NLW stage of 13.1 feet occurring approximately 3.2 hours from the start of the breach formation at Childs Bog dam.

Peak discharge, stages, and timing associated with the storm event for the four stations downstream of Childs Bog dam are shown on plate C-4. The stations are located immediately below Childs Bog dam, 100 feet below Seavers Reservoir, and 50 and 24,700 feet below Chesham Pond dam.

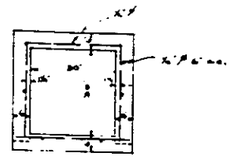
b. Sunny Day. In addition to the storm day failure, a sunny day failure simulation of Childs Bog was also performed. A sunny day failure assumes that a piping failure of the dam occurs during normal inflow to the pool. No storm event is associated with this type of failure simulation. Initial sunny day flows were assumed to be 200 cfs. We note that this is a very high typical inflow for this dam, however, it was required for computer modelling. The overall effect of this higher initial inflow is negligible in resulting flood profiles.

Peak discharge from Childs Bog dam for the sunny day breach is 6,280 cfs, resulting in a stage increase of 9.75 feet above NLW at a point immediately downstream of the dam. After routing this discharge through Seavers Reservoir dam, assuming initial pool at spillway crest and no dam failure, resulting peak discharge is 4,480 cfs producing a rise of approximately 5.2 feet above the NLW river elevation at a point 100 feet (0.02 miles) downstream of the dam. This floodwave was routed through Chesham Pond assuming that the initial impoundment was filled to spillway crest and that Chesham Pond dam does not fail. At the station 50 feet (0.01 mile) below Chesham Pond dam, peak discharge is about 4,470 cfs with an associated rise over NLW stage of about 13.5 feet. At 24,700 (4.67 miles) below Chesham Pond, in the Town of Marlborough, peak discharge is 3,020 cfs with an associated rise over NLW stage of 12.1 feet occurring approximately 3.2 hours from the start of the sunny day breach formation at Childs Bog dam.

Since the storm day failure results in a more severe flood with higher peak flows and flood elevations downstream of the dam, flood discharges, stages, and timing are not graphically depicted for the sunny day event, however, hydrograph shapes and timing are similar for both cases. Flood profiles comparing the storm and sunny day events are shown on plates C-2 and C-3.




SECTION THRU ℄ OF OUTLET PIPE



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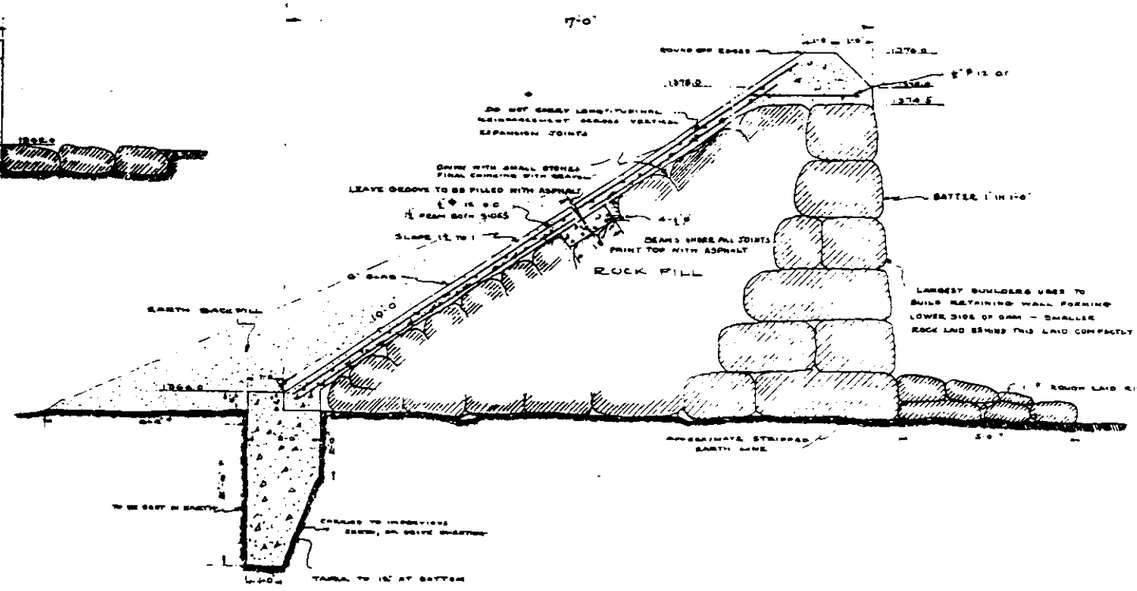
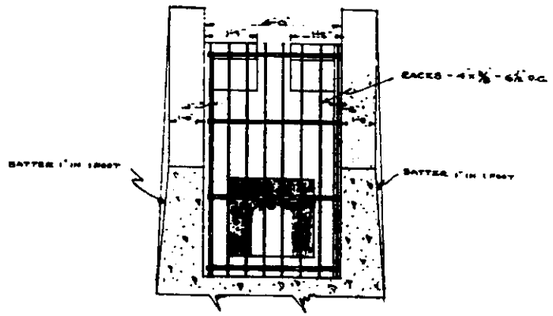
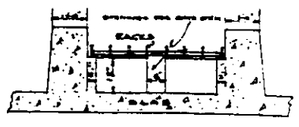



SECTION AT STA ( 2+00 )



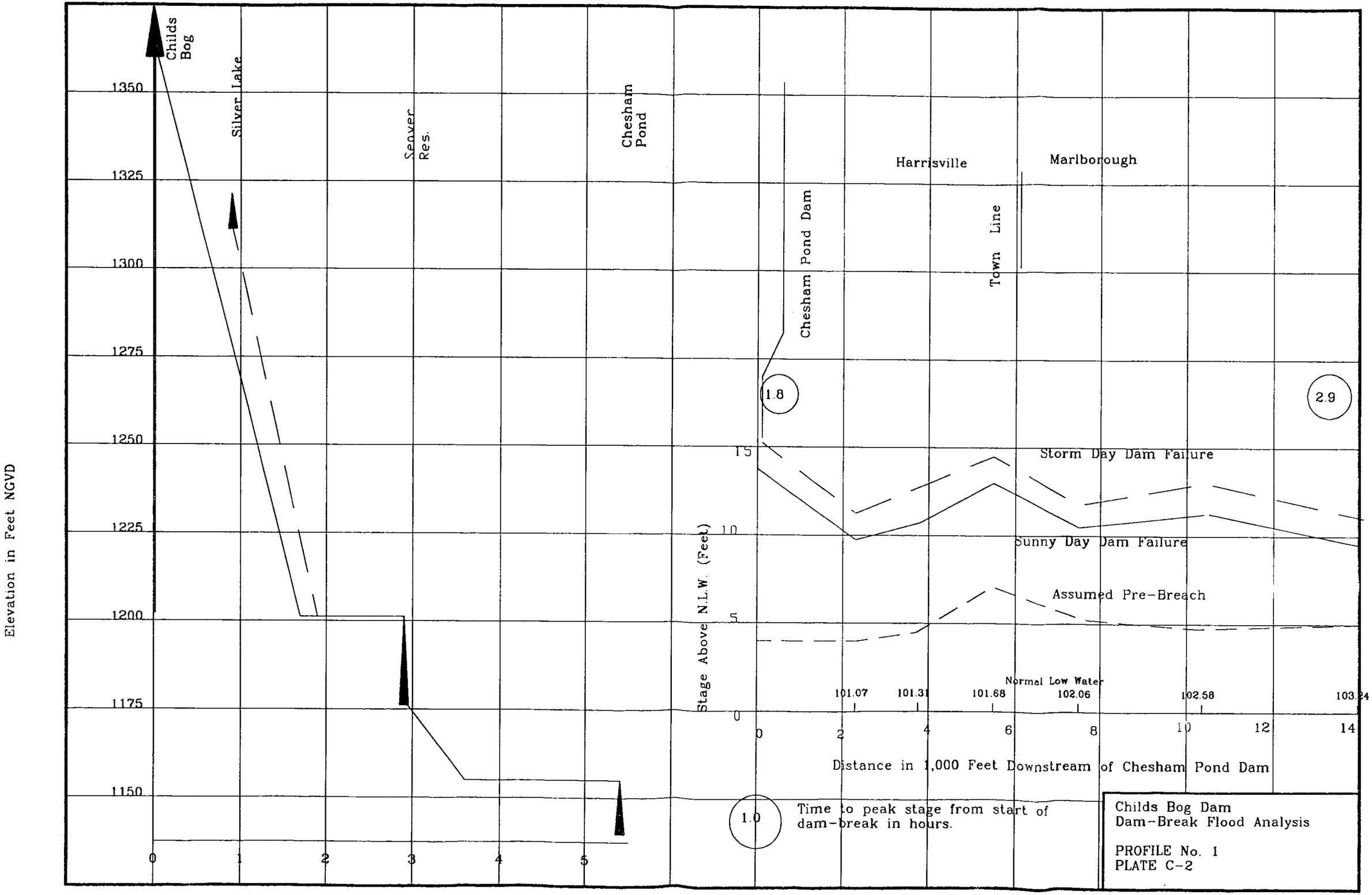

SECTION A-A




SECTION B-B

ASHUELOT GAS & ELECTRIC CO.
MINNEWAWA DEVELOPMENT
CHILDS RESERVOIR DAM
HARRISVILLE, N. H.
SECTIONS
SCALE 1"=1'-0" L.H. BHATTUCK, INC ENGRS.
AUGUST 1924 MANCHESTER, N. H.
CHIEF ENGINEER.

PLATE C-1


Childs Bog
Silver Lake
Seaver Res.
Chesham Pond
Chesham Pond Dam
Harrisville
Town Line
Marlborough
1.8
2.9
Storm Day Dam Failure
Sunny Day Dam Failure
Assumed Pre-Breach
Normal Low Water
101.07
101.31
101.68
102.06
102.58
103.24
Stage Above N.L.W. (Feet)
Elevation in Feet NGVD
Distance in 1,000 Feet Downstream of Childs Bog
Distance in 1,000 Feet Downstream of Chesham Pond Dam
1.0
Time to peak stage from start of dam-break in hours.
Childs Bog Dam
Dam-Break Flood Analysis
PROFILE No. 1
PLATE C-2

State Route 101

State Route 101

Water Street

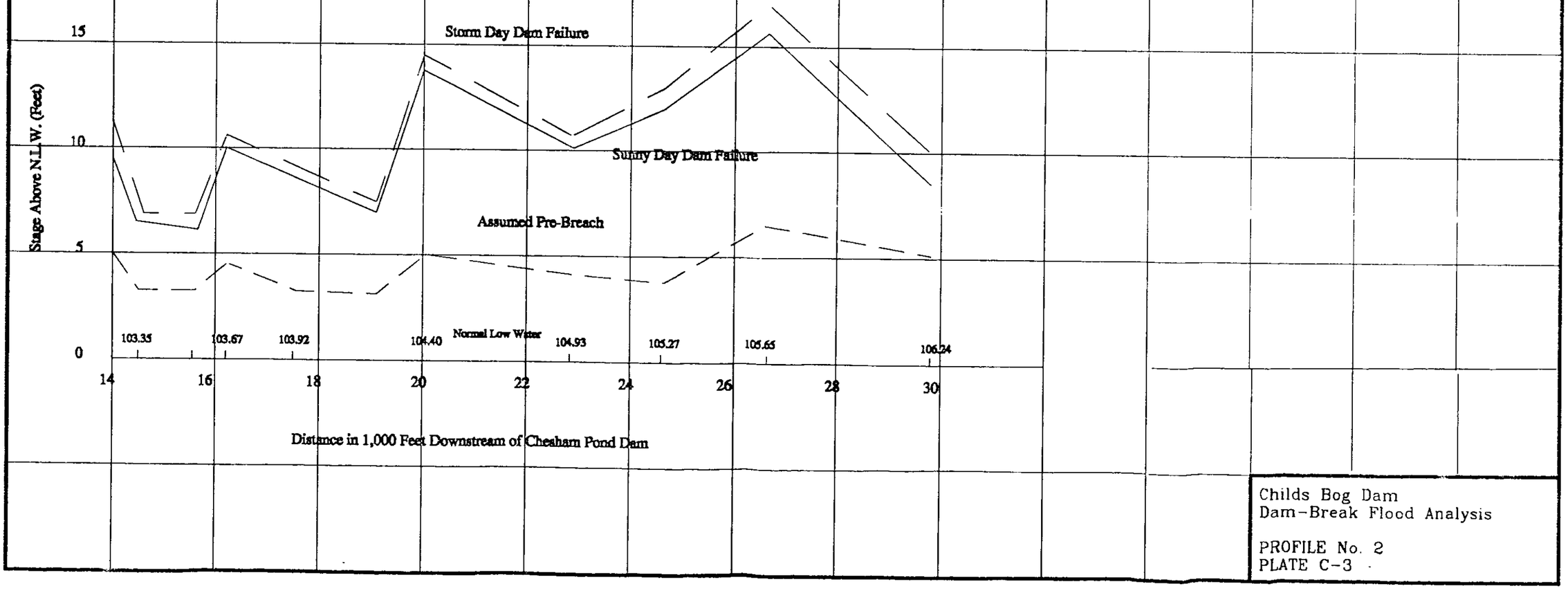
Knowlton Street

2.9

3.2

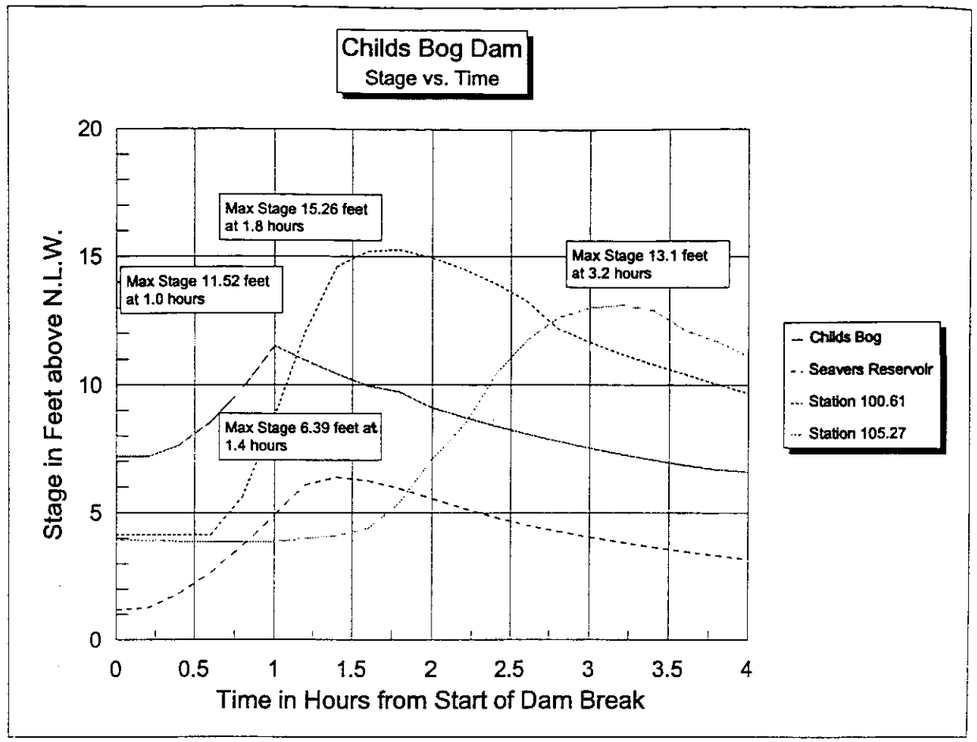
3.8

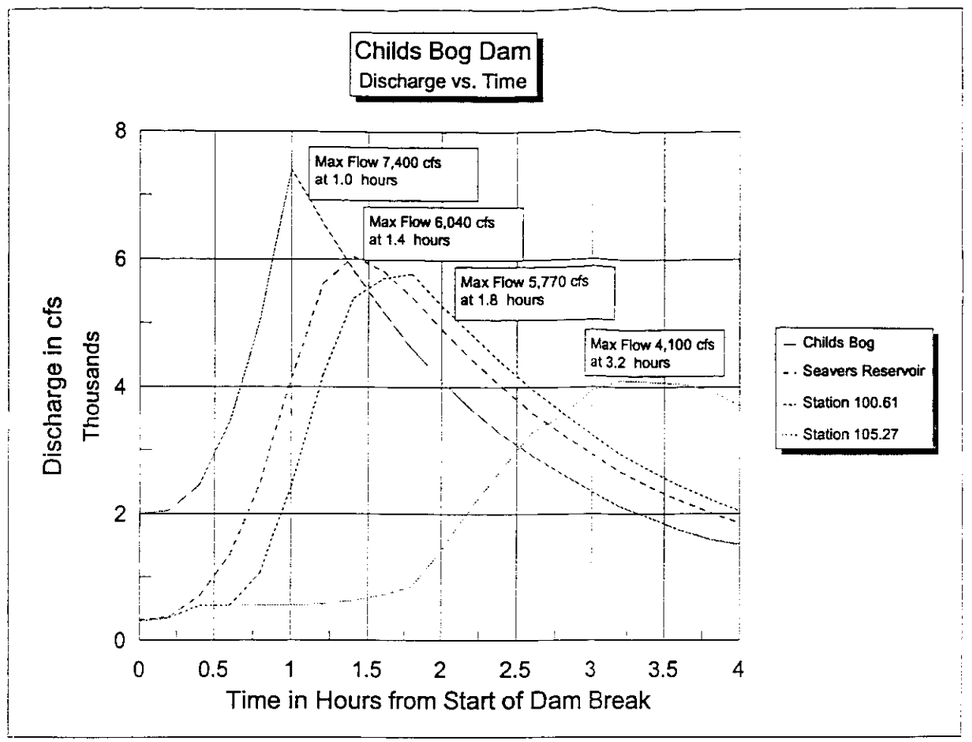
1.0 Time to peak stage from start of dam-break in hours.

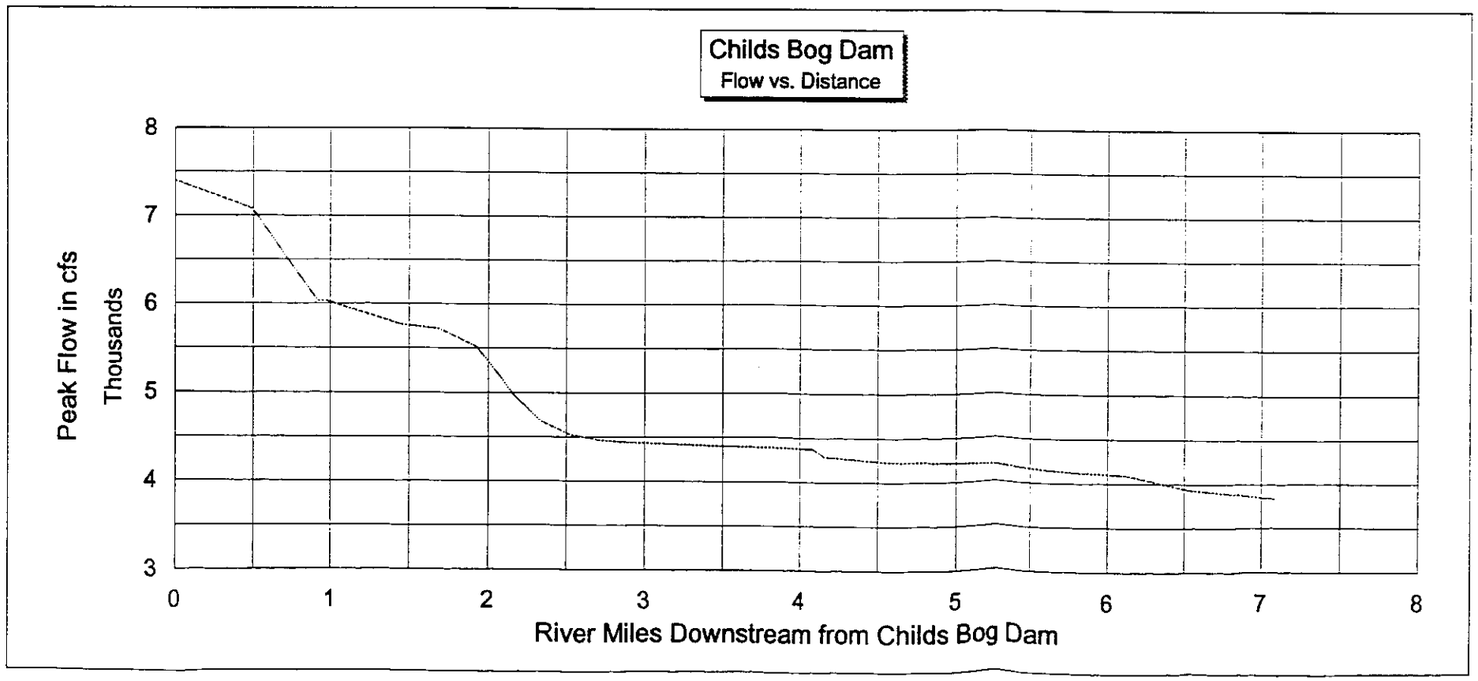



Childs Bog Dam
Dam-Break Flood Analysis

PROFILE No. 2
PLATE C-3




N.L.W. Datum (Ft. NGVD)
Sta 100.61 = 1136.8
Sta 105.27 = 705.6

**Childs Bog Dam**
Dam-Break Flood Analysis

## Base Flood Discharge Stages and Timing

PLATE C-4

# APPENDIX D

# DAM-BREAK FLOOD ANALYSIS
# SILVER LAKE DAM

# DAM-BREAK FLOOD ANALYSIS
# SILVER LAKE DAM

## TABLE OF CONTENTS



## LIST OF PLATES

# DAM-BREAK FLOOD ANALYSIS
# SILVER LAKE DAM

## 1. DAM DESCRIPTION

Silver Lake Dam is located on the southeastern point of the impoundment. It is one of the most upstream dams in a series of four dams which impound the headwaters of Minnewawa Brook. Outflow from Silver Lake flows through Seavers Reservoir and then Chesham Pond before emptying into Minnewawa Brook, located about one and one-half miles downstream. The surrounding land is primarily wooded with some sparsely placed habitable structures. Total drainage area of Silver Lake is 2.24 square miles. Information listed in table 1 was taken from the National Dam Inspection Program "Phase I Inspection Report, Silver Lake Dam," November 1978.

TABLE 1

General Dam Information

| | |
|---|---|
| *Name of Dam* | Silver Lake Dam |
| *Identification Number* | NH00062 |
| *Town* | Harrisville |
| *County and State* | Cheshire, NH |
| *Stream* | Minnewawa Brook |

Silver Lake Dam (shown on plate D-1) is a composite earth and stone dam, supplemented in some areas with concrete wall. The dam is 80 feet long with a hydraulic height of 12 feet above streambed and top of dam elevation of 1324.5 feet NGVD. The spillway consists of a concrete sluiceway channel with a maximum opening of 12 feet wide and 8 feet high with a crest elevation of 1321.0 feet NGVD. The dam has a low-level wooden sluice gate and stone culvert located in the river bed with an invert elevation of 1312± feet NGVD. Due to construction of a road across the sluiceway, the lake can only be drawn down to about elevation 1316.8 feet NGVD, the invert elevation of the culverts under the roadway.

## 2. PERTINENT DATA

The following information was taken from the Phase I Inspection Report for Silver Lake Dam.

a. Drainage Area. Silver Lake Dam controls a drainage area of 2.42 square miles of rolling, heavily wooded hills. The periphery of the lake is comprised of wooded area with some residences located near the reservoir.

b. Elevations (feet NGVD)

(1) Top of dam - 1324.5
(2) Spillway crest - 1321.0

c. Reservoir Surface (acres)

(1) Spillway crest - 340 acres
(2) Top of dam - 343 acres

d. Reservoir Storage (acre-feet)

(1) Spillway crest - 2,870 acre-feet
(2) Top of dam - 4,060 acre-feet

e. Dam

(1) Type - stone, earth, and concrete
(2) Length - 80 feet
(3) Height - 12 feet above streambed
(4) Topwidth - 35 feet
(5) Side Slopes
upstream: 17V:1H
downstream: vertical
(6) Impervious core - unknown
(7) Cutoff - concrete wall 3.5 feet±
(8) Grout curtain - none

f. Spillway

(1) Type - stoplog sluiceway
(2) Length of weir - 10.5 feet
(3) Crest elevation - 1321.0 feet NGVD
(4) Gates - none
(5) Upstream channel - Reservoir

g. Regulating Outlet

(1) Invert - 1312± feet NGVD
(2) Size - 2.7 feet by 1.7 feet
(3) Description - low-level outlet with stone culvert
(4) Control - wooden control gate and gate house

3. ASSUMED DAM-BREAK CONDITIONS

Two hypothetical dam-break scenarios were analyzed. The sunny-day and flood event cases. Dam-break parameters used in the model are listed below.

a. Initial Pool Level:

(1) Sunny day - 1321.0 feet NGVD (spillway crest elevation)
(2) Flood event - 1326.1 feet NGVD (test flood elevation from Phase I inspection report)

b. Reservoir Inflow

(1) Sunny day - 200 cfs
(2) Flood event - 815 cfs (est. September 1938)

c. Breach Invert

(1) Sunny day - 1313.5 feet NGVD
(2) Flood event - 1313.5 feet NGVD

d. Breach Base Width

(1) Sunny day - 45 feet with 1V:1H side slopes
(2) Flood event - 45 feet with 1V:1H side slopes

e. Time to Complete Formation of Breach: 1.0 hour

f. Downstream Channel Roughness (Mannings "n"): 0.06 to 0.14

4. MODEL RESULTS

Resulting peak stage flood profiles for both the flood event and sunny day dam-break scenarios are shown on plates D-2 and D-3. Profiles are shown in feet above normal summertime (July-August) low water (NLW) because below water channel geometry was known for relatively few downstream sections and detailed survey information was only obtained

at each of the dams. Users of the information can establish depth of flooding at particular properties by establishing its relative elevation with respect to the adjacent stream level. Variations in depth above NLW progressing downstream are attributable to changes in natural stream hydraulic capacity as well as changes in peak discharge.

For the dam-break analyses, the stream channel below Silver Lake was modeled in three reaches. The first reach is from Silver Lake dam to Seavers Reservoir. These analyses assume that the raodway across the sluiceway is completely washed-out during dam failure to allow the breach to fully develop at the dam. The next reach is from the dam at Seavers Reservoir through Chesham Pond to river station 103.24, about 13,900 feet (2.64 miles) downstream. The second reach extends from station 103.35 to the end of the study beyond the Town of Marlborough at station 106.24 (about 29,800 feet, 5.64 miles, below Chesham Pond). The outflow hydrograph of the first reach was used as the inflow hydrograph to the second reach. Similar methodology was applied for the second and third reaches.

Outflow from two impoundments on a tributary stream, Howe and Russell Reservoirs, enters Minnewawa Brook about 6,900 feet (1.3 miles) below Chesham Pond dam. Estimated flood event discharge from these impoundments is 2,400 cfs (based on the September 1938 flood of record). Dam-break modelling was performed both with and without this additional discharge entering Minnewawa Brook. Analysis of resulting peak stages at the downstream limit of study in Marlborough revealed only a minor difference between the two cases because significant attenuation occurs throughout the river valley. As a result, final adopted dam-break simulations were performed without including this flow.

a. Flood Event. Flood event simulation assumes that inflow to the impoundment was approximately equal to the flood of record, September 1938, and that the dam fails by overtopping. Peak discharge from Silver Lake for the storm day failure is 8,750 cfs resulting a river stage rise of about 11.0 feet above NLW immediately downstream of the dam. After being routed through Seavers Reservoir dam, assuming initial pool at spillway crest and no dam failure, resulting peak discharge is 7,780 cfs producing a rise of approximately 7.6 feet above the NLW river elevation at a point 100 feet (0.02 miles) downstream of the dam. This floodwave was routed through Chesham Pond assuming that the initial impoundment was filled to spillway crest and that Chesham Pond dam does not fail. At the station 50 feet (0.01 mile) below Chesham Pond dam, peak discharge is about

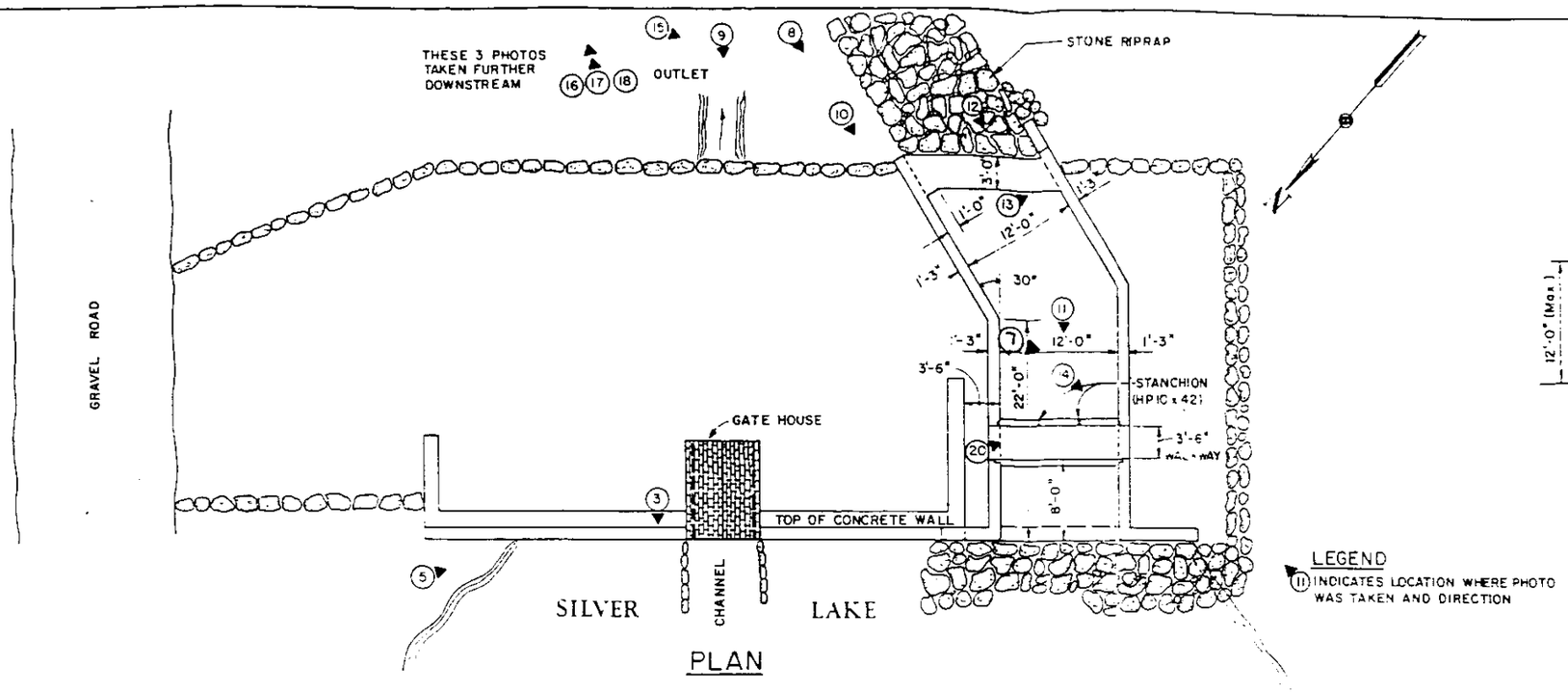
7,590 cfs with an associated rise over NLW stage of about 16.8 feet. At 24,700 feet (4.67 miles) below Chesham Pond, in the Town of Marlborough, peak discharge is 6,090 cfs with an associated rise over NLW stage of 17.9 feet occurring approximately 3.8 hours from the start of the breach formation at Silver Lake dam.

Peak discharge, stages, and timing associated with the storm event for the four stations downstream of Silver Lake dam are shown on plate D-4. The stations are located immediately below Silver Lake dam, 100 feet below Seavers Reservoir, and 50 and 24,700 feet below Chesham Pond dam.

b. Sunny Day. In addition to the storm day failure, a sunny day failure simulation of Silver Lake was also performed. A sunny day failure assumes that a piping failure of the dam occurs during normal inflow to the pool. No storm event is associated with this type of failure simulation. Initial sunny day flows were assumed to be 200 cfs. We note that this is a very high typical inflow for this dam, however, it was required for computer modelling. The overall effect of this higher initial inflow is negligible in resulting flood profiles.

Peak discharge from Silver Lake dam for the sunny day breach is 4,970 cfs, resulting in a stage increase of 7.2 feet above NLW at a point immediately downstream of the dam. After routing this discharge through Seavers Reservoir dam, assuming initial pool at spillway crest and no dam failure, resulting peak discharge is 4,060 cfs producing a rise of approximately 4.9 feet above the NLW river elevation at a point 100 feet (0.02 miles) downstream of the dam. This floodwave was routed through Chesham Pond assuming that the initial impoundment was filled to spillway crest and that Chesham Pond dam does not fail. At the station 50 feet (0.01 mile) below Chesham Pond dam, peak discharge is about 4,055 cfs with an associated rise over NLW stage of about 12.8 feet. At 24,700 feet (4.67 miles) below Chesham Pond, in the Town of Marlborough, peak discharge is 3,270 cfs with an associated rise over NLW stage of 15.2 feet occurring approximately 3.6 hours from the start of the sunny day breach formation at Silver Lake dam.

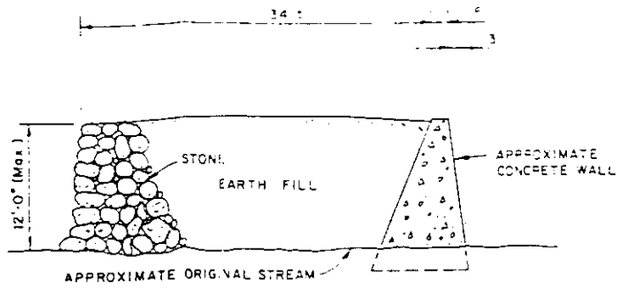
Since the storm day failure results in a more severe flood with higher peak flows and flood elevations downstream of the dam, flood discharges, stages, and timing are not graphically depicted for the sunny day event, however, hydrograph shapes and timing are similar for both cases. Flood profiles comparing the storm and sunny day events are shown on plates D-2 and D-3.




PLAN

LEGEND

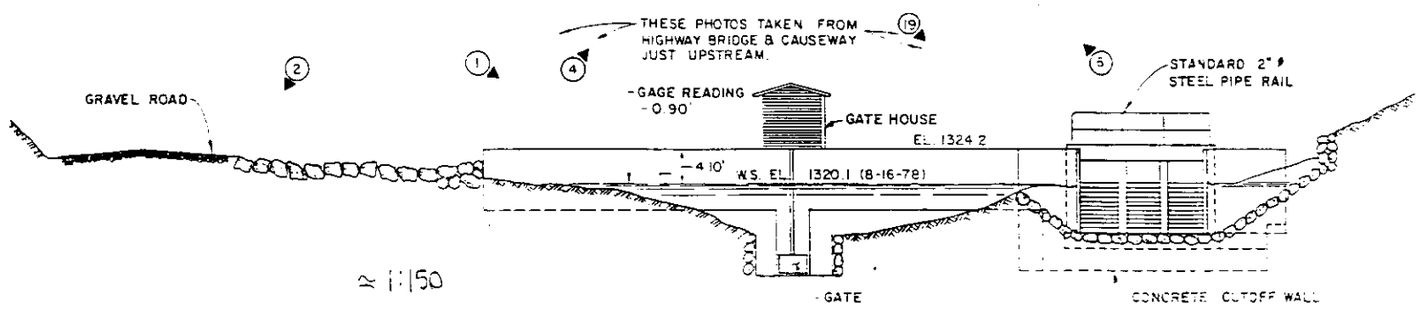
(11) INDICATES LOCATION WHERE PHOTO WAS TAKEN AND DIRECTION




SECTION THRU DAM

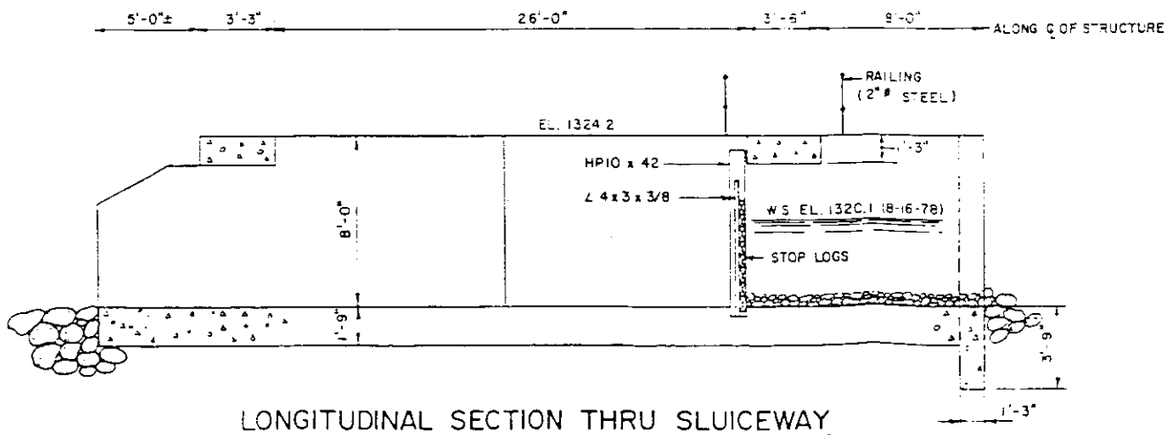
(AT SLUICEWAY)


SECTION THRU DAM AT LEFT ABUTMENT




≈ 1:150

ELEVATION




LONGITUDINAL SECTION THRU SLUICEWAY

(ALONG ℄)

NOTES:

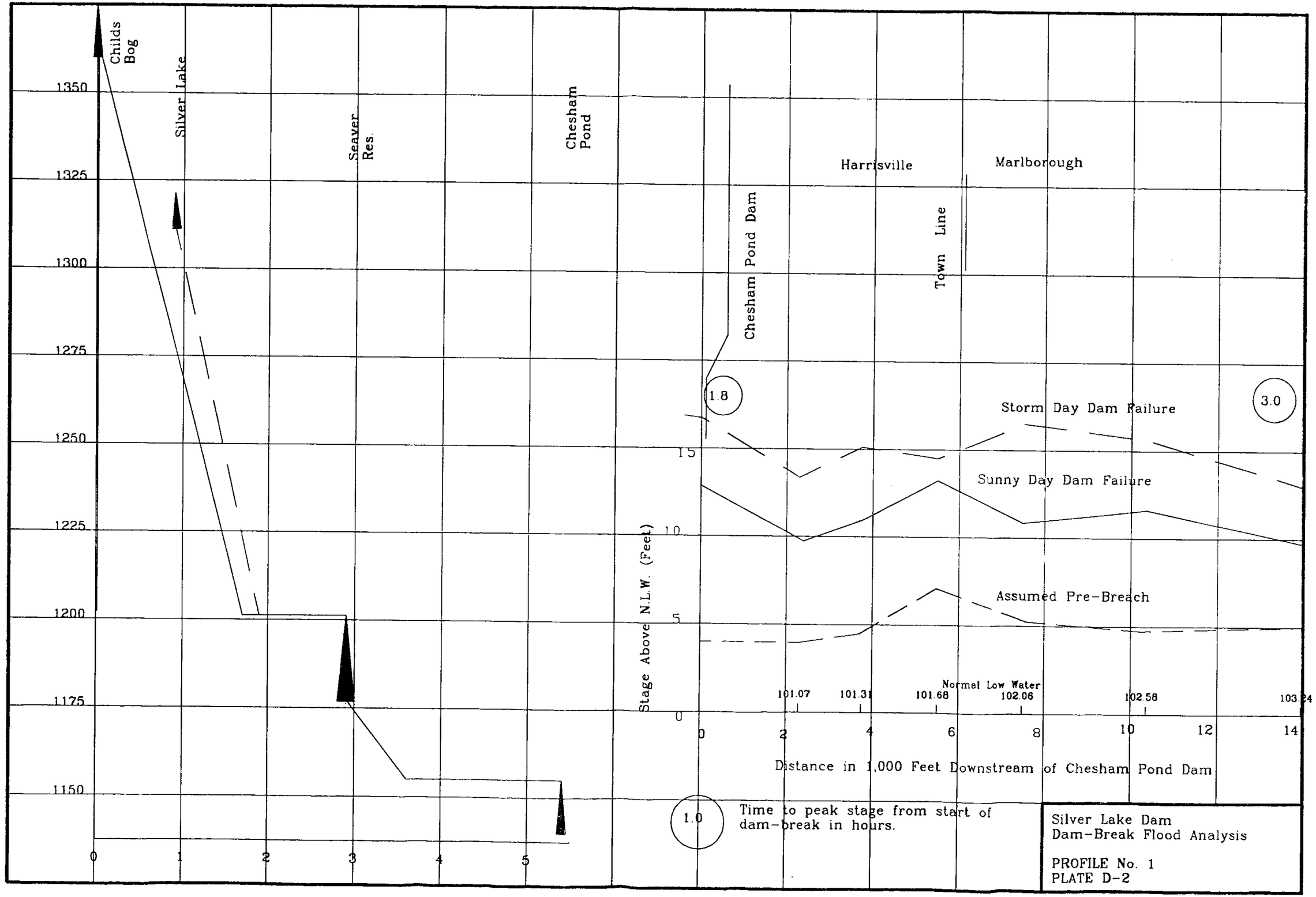
1. THE ELEVATIONS SHOWN ARE BASED ON AN ELEVATION OF 1324 SHOWN ON THE USGS QUADRANGLE SHEET ASSUMED TO BE POOL ELEVATION AT 0.00 GAUGE READING.
2. THE INFORMATION SHOWN ON THESE DRAWINGS IS BASED ON THE ORIGINAL CONSTRUCTION PLANS AND VISUAL OBSERVATIONS MADE DURING THE FIELD INSPECTION. DIMENSIONS OR MATERIALS INDICATED ON THESE DRAWINGS WHICH WERE BELOW SPACE OR WATER DURING THE TIME OF INSPECTION WERE NOT VERIFIED.

NATIONAL PROGRAM OF INSPECTION OF NON-FED DAMS

# SILVER LAKE DAM

SILVER LAKE OUTLET HARRISVILLE, NEW HAMPSHIRE

PLATE D-1


Childs Bog
Silver Lake
Seaver Res.
Chesham Pond
Harrisville
Marlborough
Chesham Pond Dam
Town Line
1.8
3.0
Storm Day Dam Failure
Sunny Day Dam Failure
Assumed Pre-Breach
Normal Low Water
101.07
101.31
101.68
102.06
102.58
103.24
1350
1325
1300
1275
1250
1225
1200
1175
1150
15
10
5
0
0
1
2
3
4
5
0
2
4
6
8
10
12
14
Elevation in Feet NGVD
Stage Above N.L.W. (Feet)
Distance in 1,000 Feet Downstream of Childs Bog
Distance in 1,000 Feet Downstream of Chesham Pond Dam
1.0
Time to peak stage from start of dam-break in hours.
Silver Lake Dam
Dam-Break Flood Analysis
PROFILE No. 1
PLATE D-2

State Route 101

State Route 101

Water Street

Knowlton Street

3.0

3.8

4.2

1.0

Time to peak stage from start of dam-break in hours.

Storm Day Dam Failure

Sunny Day Dam Failure

Assumed Pre-Breach

Stage Above N.L.W. (Feet)

20

15

10

5

0

103.35

103.67

103.92

104.40

Normal Low Water

104.93

105.27

105.65

106.24

14

16

18

20

22

24

26

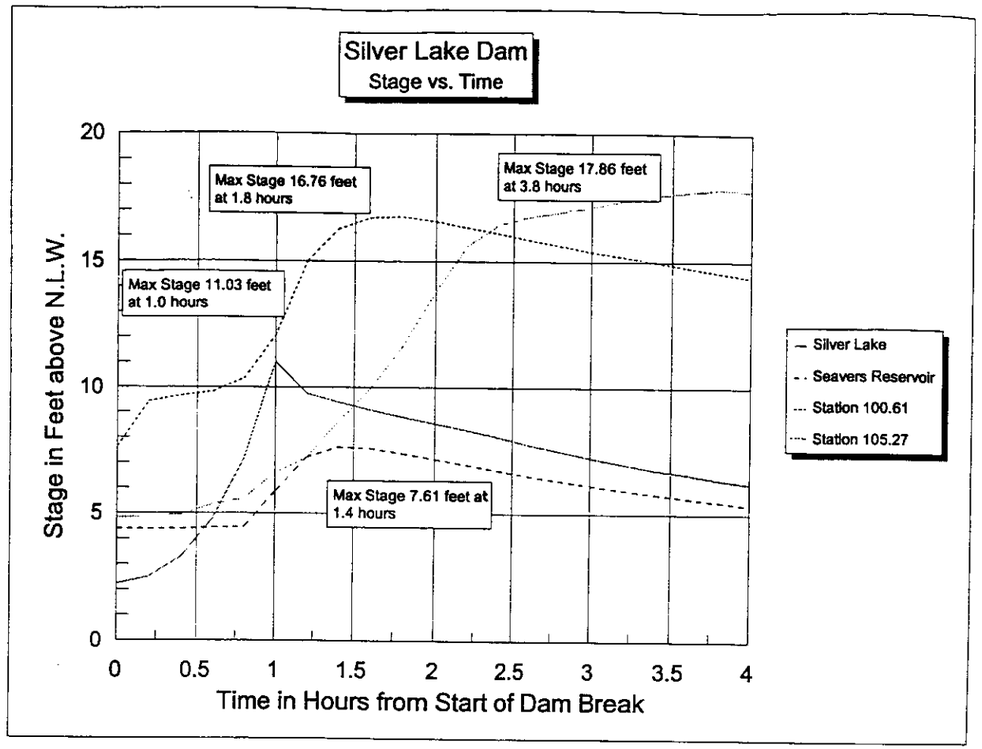
28

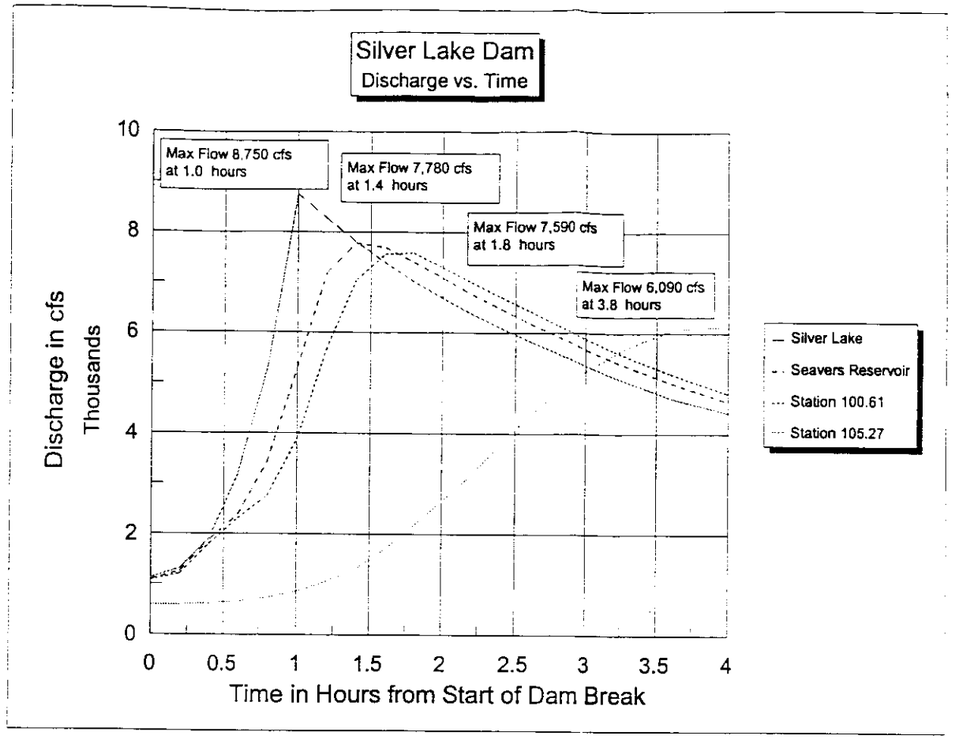
30

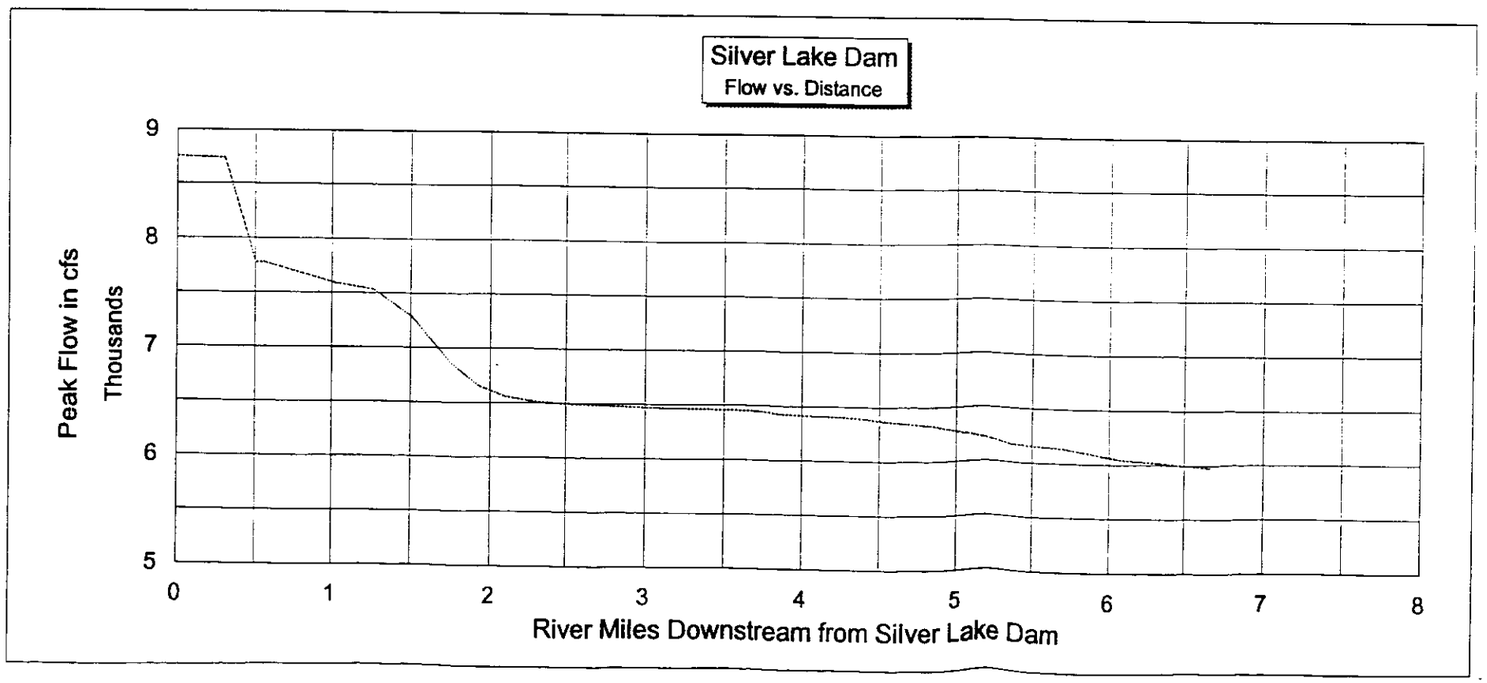
Distance in 1,000 Feet Downstream of Chesham Pond Dam

Silver Lake Dam
Dam-Break Flood Analysis

PROFILE No. 2
PLATE D-3




N.L.W. Datum (Ft. NGVD)
Sta 100.61 = 1136.8
Sta 105.27 = 705.6

**Silver Lake Dam**
Dam-Break Flood Analysis

**Base Flood Discharge Stages and Timing**

PLATE D-4

# APPENDIX E

# DAM-BREAK FLOOD ANALYSIS
# MULTIPLE DAM FAILURES

# DAM-BREAK FLOOD ANALYSIS
# MULTIPLE DAM FAILURES

## TABLE OF CONTENTS



## LIST OF TABLES

# DAM-BREAK FLOOD ANALYSIS
# MULTIPLE DAM FAILURES

## 1. ASSUMED DAM-BREAK CONDITIONS

Several hypothetical multiple dam-break scenarios were analyzed. Different combinations of multi-dam failures were simulated and routed downstream to Marlborough. Dam-break parameters used in these simulations are similar to those used for each individual dam-break scenario and are described in Appendices A through D.

In addition to analyzing combinations of the four dams in the Minnewawa Brook headwaters, the consequences of a concurrent failure at Howe Reservoir was studied. Results of all of the multiple failures are discussed below.

## 2. MODEL RESULTS

A summary of resulting peak stage, flow, and timing at Marlborough for each of the multiple dam failure simulations analyzed is presented in table E-1 at the end of this section. Stages are described in feet above normal summertime (July-August) low water (NLW) because below water channel geometry was known for relatively few downstream sections and detailed survey information was only obtained at each of the dams. Users of the information can determine depth of flooding at particular properties by establishing its relative elevation with respect to the adjacent stream level.

Outflow from Howe and Russell Reservoirs enters Minnewawa Brook about 6,900 feet (1.3 miles) below Chesham Pond dam. Estimated peak dam-break discharge from these impoundments is 24,410 cfs (based on the November 1985 "Howe Reservoir Dam, Dam-Break Flood Analysis Report"). Dam-break modelling was performed both with and without this additional discharge entering Minnewawa Brook.

a. Two Dam Failure (Silver Lake and Seavers Reservoir). Based on the results of the individual breach analyses, Seavers Reservoir and Silver Lake had the highest peak breach discharges. As a result, a possible worst case scenario of the upstream Silver Lake failing and causing a failure at Seavers Reservoir was analyzed and routed downstream to the Town of Marlborough. Chesham Pond Dam was not assumed to fail primarily due to the submergence of the dam during high flows and due to the relatively small height of the dam. During the failure scenario involving Silver

Lake and Seavers Reservoir, the tailwater below Chesham Pond dam is over the top of the dam. Due to this submergence, flows were assumed to overtop Chesham Pond dam without causing failure.

This scenario assumes that Silver Lake dam breaches under the same conditions as the storm event breach described in Appendix D. Peak discharge from Silver Lake for the storm day failure is 8,750 cfs resulting in a river stage rise of about 11.0 feet above NLW immediately downstream of the dam. After being routed through Seavers Reservoir dam, assuming initial pool at spillway crest and dam failure when the pool reaches top of dam elevation, resulting peak breach discharge out of Seavers Reservoir is 23,530 cfs producing a rise of approximately 16.0 feet above the NLW river elevation at a point 100 feet (0.02 miles) downstream of the dam. This floodwave was routed through Chesham Pond assuming that the initial impoundment was filled to spillway crest and that Chesham Pond dam does not fail. At the station 50 feet (0.01 mile) below Chesham Pond dam, peak discharge is about 15,590 cfs with an associated rise over NLW stage of about 16.6 feet. At 24,700 feet (4.67 miles) below Chesham Pond, in the Town of Marlborough, peak discharge is 10,140 cfs with an associated rise over NLW stage of 19.9 feet occurring approximately 3.8 hours from the start of the breach formation at Silver Lake dam.

b. Three Dam Failure (Either Silver Lake or Childs Bog with Seavers Reservoir and Chesham Pond). In these scenarios, either Silver Lake or Childs Bog dam fails, causing a failure at Seavers Reservoir. The resulting inflow to Chesham Pond was assumed to cause failure of the Chesham Pond dam when it gets overtopped, and the resulting breach discharge hydrograph was routed downstream to the Town of Marlborough.

(1) Silver Lake Failure. This scenario assumes that Silver Lake breaches under the same conditions as the storm event breach described in Appendix D. Peak discharge from Silver Lake for the storm day failure is 8,750 cfs resulting in a river stage rise of about 11.0 feet above NLW immediately downstream of the dam. After being routed through Seavers Reservoir dam, assuming initial pool at spillway crest and dam failure when the pool reaches top of dam elevation, resulting peak breach discharge out of Seavers Reservoir is 23,530 cfs producing a rise of approximately 16.0 feet above the NLW river elevation at a point 100 feet (0.02 miles) downstream of the dam. This floodwave was routed through Chesham Pond assuming that the initial impoundment was filled to spillway crest and that Chesham Pond dam fails when the pool reaches the top of the

dam. At the station 50 feet (0.01 mile) below Chesham Pond dam, peak discharge is about 17,720 cfs with an associated rise over NLW stage of about 18.2 feet. This attenuation in peak discharge (23,530 cfs inflow versus 17,720 cfs outflow) is due primarily to the river valley geometry in this reach. Chesham Pond dam is located in a very narrow valley section, which, even without the dam, tends to store water upstream due to the limited conveyance through the section. In addition, this area is affected by high tailwater downstream, which tends to further attenuate peak discharges through this section. At 24,700 feet (4.67 miles) below Chesham Pond, in the Town of Marlborough, peak discharge is 11,910 cfs with an associated rise over NLW stage of 20.9 feet occurring approximately 3.3 hours from the start of the breach formation at Silver Lake dam.

(2) Childs Bog Failure. This scenario assumes that Childs Bog dam breaches under the same conditions as the storm event breach described in Appendix C. Childs Bog dam peak breach discharge is 7,400 cfs immediately below the dam with a resulting stage rise of 11.5 feet above NLW. After being routed through Seavers Reservoir dam, assuming initial pool at spillway crest and dam failure when the pool reaches top of dam elevation, resulting peak breach discharge out of Seavers Reservoir is 23,175 cfs producing a rise of approximately 15.9 feet above the NLW river elevation at a point 100 feet (0.02 miles) downstream of the dam. This floodwave was routed through Chesham Pond assuming that the initial impoundment was filled to spillway crest and that Chesham Pond dam fails when the pool reaches the top of the dam. At the station 50 feet (0.01 mile) below Chesham Pond dam, peak discharge is about 16,100 cfs with an associated rise over NLW stage of about 17.3 feet. This attenuation in the peak discharge is discussed in the paragraph above. At 24,700 feet (4.67 miles) below Chesham Pond, in the Town of Marlborough, peak discharge is 10,970 cfs with an associated rise over NLW stage of 20.8 feet occurring approximately 3.2 hours from the start of the breach formation at Childs Bog dam.

c. Four Dam Failure (All Minnewawa Brook Dams). In this scenario, both Silver Lake and Childs Bog dam fail simultaneously. Breach discharge from these dams causes a failure at Seavers Reservoir when the pool exceeds the test flood elevation (discussed in Appendix B). The resulting inflow to Chesham Pond was assumed to cause failure of the dam when the pool reaches its test flood elevation (see Appendix A), and the resulting breach discharge hydrograph was routed downstream to the Town of Marlborough.

This scenario assumes that Silver Lake and Childs Bog Dam breach under the same conditions as the storm event breach described in the individual appendices. Peak discharge from Silver Lake for the storm day failure is 8,750 cfs resulting in a river stage rise of about 11.0 feet above NLW immediately downstream of the dam. Childs Bog dam peak breach discharge is 7,400 cfs immediately below the dam with a resulting stage rise of 11.5 feet above NLW. After being combined and routed through Seavers Reservoir dam, assuming initial pool at spillway crest and dam failure when the pool reaches top of dam elevation, resulting peak breach discharge out of Seavers Reservoir is 31,260 cfs producing a rise of approximately 18.9 feet above the NLW river elevation at a point 100 feet (0.02 miles) downstream of the dam. This floodwave was routed through Chesham Pond assuming that the initial impoundment was filled to spillway crest and that Chesham Pond dam fails when the pool reaches the top of the dam. At the station 50 feet (0.01 mile) below Chesham Pond dam, peak discharge is about 24,760 cfs with an associated rise over NLW stage of about 22.1 feet. Causes of this attenuation in peak discharge are discussed above. At 24,700 feet (4.67 miles) below Chesham Pond, in the Town of Marlborough, peak discharge is 17,410 cfs with an associated rise over NLW stage of 24.8 feet occurring approximately 3.2 hours from the start of the breach formation at Silver Lake dam. This stage at Marlborough is approximately 4 feet above FEMA's 500-year water surface elevation from the November 3, 1981 "Flood Insurance Study, Town of Marlborough, Cheshire County, New Hampshire."

d. Catastrophic Regional Failure (All Minnewawa Brook Dams with Howe Reservoir). In this scenario, both Silver Lake and Childs Bog dam fail simultaneously. Breach discharge from these dams causes a failure at Seavers Reservoir when the pool exceeds the test flood elevation (discussed in Appendix B). The resulting inflow to Chesham Pond was assumed to cause failure of the dam when the pool reaches its test flood elevation (see Appendix A). This breach discharge hydrograph was then combined with the breach discharge hydrograph from Howe Reservoir and the resulting discharge hydrograph was routed downstream to the Town of Marlborough.

The results of this analysis are the same as the previous one except that downstream of Chesham Pond dam, peak discharge resulting from the Howe Reservoir breach of 24,410 cfs is combined with the Chesham Pond dam-break hydrograph and routed to Marlborough. At 24,700 feet (4.67 miles) below Chesham Pond, in the Town of Marlborough, peak discharge is 40,070 cfs with an associated rise over NLW

stage of 32.4 feet occurring approximately 2.9 hours from the start of the breach formation at Silver Lake dam. This stage at Marlborough is approximately 11 feet above FEMA's 500-year water surface elevation from the November 3, 1981 "Flood Insurance Study, Town of Marlborough, Cheshire County, New Hampshire."

TABLE E-1

Summary of Peak Discharges, Stages, and Timing
Multiple Dam-Break Scenarios

| Dam-Break Scenario | Marlborough | | |
|---|---|---|---|
| | Flow (cfs) | Stage (NLW) | Time[1] |
| Silver Lake & Seavers Reservoir Combined Failure | 10,140 | 19.9 | 3.8 |
| Silver Lake, Seavers Reservoir, and Chesham Pond Combined Failure | 11,910 | 20.9 | 3.3 |
| Childs Bog, Seavers Reservoir, and Chesham Pond Combined Failure | 10,970 | 20.8 | 3.2 |
| All Minnewawa Brook Dams | 17,410 | 24.8 | 3.2 |
| All Minnewawa Brook Dams and Howe Reservoir[2] | 40,070 | 32.4 | 2.9 |

[1]Note: Time is in hours from start of most upstream dambreak failure.
[2]Estimated peak dam-break discharge from Howe and Russell Reservoirs is 24,410 cfs (based on the November 1985 "Howe Reservoir Dam, Dam-Break Flood Analysis Report").

Differences in amount of attenuation and timing of peak discharges are due primarily to differences in the volume of flood water in the breach hydrographs.